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THE
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VOL. XIV. JUNE, 1937 No. 165

Editorial

The Design of Coupling Filters in Broadcast Receivers

THE filter consisting of two coupled oscillatory circuits has always formed an important element in the broadcast receiver. In 1916 the writer described* a simple method of explaining the action of such a filter and of calculating the performance. The method had the great advantage of giving one a clear insight into what happens in such a filter as the frequency is varied over the band.

Several papers on the subject have recently been published in Germany, with special reference to the conditions necessary for obtaining symmetry between the two sides of the band when the two coupled circuits are not identically similar. As we showed in 1916, two circuits coupled by the mutual inductance between their coils need not be identical; so long as they have the same resonant frequencies and the same decrements they will be as symmetrical in operation as if they had equal inductances and equal capacitances. If in Fig. 1, $C_2 = nC_1$ and $L_1 = nL_2$, where n is any number whatever, the circuits will have the same resonant frequency, and if $R_1 = nR_2$ they will have the same decrement. If now the two condensers are charged but so that $V_1 = \sqrt{n}V_2$, the electrostatic energies will be equal, and on suddenly discharging the two condensers, $I_2 = \sqrt{n}I_1$ at every moment. The two currents die away together as a single damped oscillation of one definite frequency, but what that frequency is depends on whether the condensers were charged in the same or opposite directions, that is, on whether the currents in the two coils flow in conjunction or in opposition. In the former case the effective inductance of each circuit is increased, whereas in the latter it is decreased. It is thus seen that such a pair of coupled oscillatory circuits has two possible resonant frequencies, viz., $f_0/\sqrt{1+k}$ and $f_0/\sqrt{1-k}$ where f_0 is the resonant frequency of either circuit alone and $k = M/\sqrt{L_1 L_2}$ is the coupling coefficient, or, calling the lower and upper frequencies f_1 and f_2,

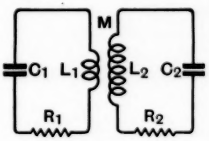

Fig. 1.

$$\omega_1^2 = \frac{1}{C_1(L_1 + \sqrt{n}M)} \quad \text{and}$$

$$\omega_2^2 = \frac{1}{C_1(L_1 - \sqrt{n}M)}.$$

We shall now consider the type of coupling shown in Fig. 2(*a*) in which there are no separate circuits, but in which the coil M' is common to both. We need not consider the simple case in which the circuits are similar, but pass at once to the case in which

* See references at the end.

$L_1' = nL_2'$ and $C_2 = nC_1$. We thus assume that the circuits C_1L_1' and C_2L_2' have the same resonant frequency when M' is short-circuited. If now the two condensers were charged as shown and so that $V_1 = nV_2$ and simultaneously discharged, the discharge currents of the two condensers would be

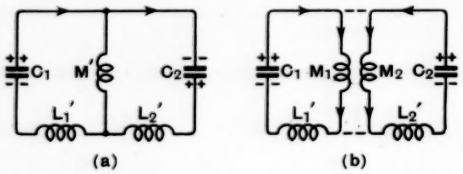

Fig. 2.

equal and a damped oscillatory current would flow around the circuit $C_1L_1'L_2'C_2$ without being influenced in any way by M', across which there would be no p.d. This then gives us one of the resonant frequencies of the combination; it is determined by $C_1L_1' = C_2L_2'$, ignoring M'.

If now we picture M' replaced by M_1 and M_2 in parallel where $M_1 = (1 + n)M'$ and $M_2 = (1 + 1/n)M'$ so that $M_1 = nM_2$ then $C_1(L_1' + M_1) = C_2(L_2' + M_2)$ and on charging the condensers as shown in Fig. 2(*b*) to the same voltage and simultaneously discharging them, the oscillatory currents in the two circuits $C_1L_1'M_1$ and $C_2L_2'M_2$ will die away synchronously and nothing would be affected by removing the links connecting M_1 to M_2. This gives us then the second resonant frequency of this filter and it is determined by $C_1[L_1' + (1 + n)M'] = C_2[L_2' + (1 + 1/n)M']$. By comparing the results obtained for Figs. 1 and 2 it is easily seen that the results are the same if we make

$$L_1 = L_1' + \frac{n+1}{2}M'$$

and $$M = \frac{n+1}{2\sqrt{n}} \cdot M'.$$

We are neglecting the small effects due to differences of decrement. An analogous problem arises when a condenser replaces the inductance M' as the common element. This case was considered in detail in our 1916 paper. The important point to notice in both cases is that the circuits must be of the same resonant frequency when the common element is short-circuited.

Fig 3(*a*) shows a filter with a condenser as the common element. If $L_1C_1' = L_2C_2'$ and the condensers be charged with equal quantities, as shown in Fig. 3(*a*), and simultaneously discharged, the coupling condenser C_3 will play no part in the resulting oscillatory discharge. If the common condenser C_3 is replaced by two condensers aC_3 and $(1 - a)C_3$ in parallel as in Fig. 3(*b*), then if $(1 - a)C_3 = naC_3$, the two circuits L_1, C_1, aC_3, and L_2, C_2, $(1 - a)C_3$ will have the same resonant frequency and this will be the higher of the two resonant frequencies of the filter. If $1 - a = na$ then $a = \frac{1}{n+1}$ and $(1 - a) = n(n + 1)$. The resultant capacitance of C_1' and $C_3/(n + 1)$ in series is $\frac{C_1'C_3}{C_1'(n+1)+C_3}$ and $1/\omega_2^2 = \frac{L_1C_1'C_3}{C_1'(n+1)+C_3}$ whence

$$\omega_2^2 = \frac{1}{L_1C_1'} + \frac{n+1}{L_1C_3} = \frac{1}{L_1C_1'}\left[1 + (n+1)\frac{C_1'}{C_3}\right]$$

while $\omega_1^2 = \frac{1}{L_1C_1'}$. Now the three condensers which are star connected between the points XYZ can be replaced by three mesh-connected condensers as shown in Fig. 4(*a*), in accordance with the well-known star-mesh

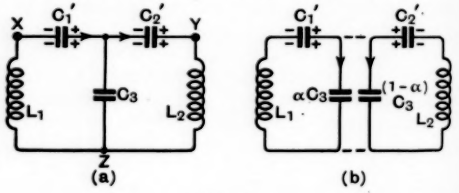

Fig. 3.

transformation. This gives us another common type of coupled filter circuit and it was in connection with this type that the discussion on dissymmetry arose in the German technical press.

The formulae for star-mesh transformation give the following results for the values of K_1, K_2, and K_3:

$$K_1 = \frac{C_1'C_3}{C_1'+C_2'+C_3} \text{ or } \frac{1}{K_1} = \frac{1}{C_1'} + (n+1)\frac{1}{C_3}$$

$$K_2 = \frac{C_2'C_3}{C_1'+C_2'+C_3} \text{ or } \frac{1}{K_2} = \frac{1}{C_2'} + \frac{n+1}{n}\cdot\frac{1}{C_3}$$

$$K_3 = \frac{C_1'C_2'}{C_1'+C_2'+C_3} \text{ or } \frac{1}{K_3} = \frac{1}{C_1'} + \frac{1}{C_2'} + \frac{C_3}{C_1'C_2'}$$

A similar transformation could be applied to Fig. 2, giving a filter like Fig. 4(*a*), but with an inductance in place of K_3.

Figs. 4(*a*) and 4(*b*) show the two modes of resonant vibration. In Fig. 4(*a*) if the two condensers are charged as shown to the same voltage and simultaneously discharged, K_3 will play no part in the oscillatory discharge, since $K_1L_1 = K_2L_2$ as may be seen from the above formulae for $1/K_1$ and $1/K_2$ which only differ by the factor $n = C_2'/C_1'$.

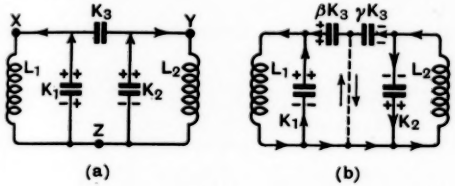

Fig. 4.

In Fig. 4(*b*) the coupling condenser K_3 is replaced by two condensers βK_3 and γK_3 in series, giving the same resultant K_3, but such that $\gamma/\beta = n = K_2/K_1$. This is obtained by making $\beta = 1 + 1/n$ and $\gamma = 1 + n$. If the condensers were charged as shown, so that the charge in $K_1 + \beta K_3$ was equal to that in $K_2 + \gamma K_3$, and then simultaneously discharged, no current would flow through the dotted connection, which could be short-circuited without interfering with the damped oscillation which would take place. To find the two resonant frequencies of this filter we have therefore

$$\omega_1^2 = \frac{1}{L_1[K_1 + (1 + 1/n)K_3]}$$

and $$\omega_2^2 = \frac{1}{L_1K_1}.$$

These are, of course, the same values as found above for Fig. 3, as can readily be shown by substituting the values for K_1 and K_3 in terms of C_1' and C_3. It will be noticed, however, that the filter circuit without the coupling condenser gives the lower frequency in Fig. 3, but the higher frequency in Fig. 4, a point of some importance in filter design.

Whereas with the separate circuits of Fig. 1 a change of coupling, and therefore of width of band, has a negligibly small effect on the mean frequency, in all the other cases any change of coupling causes a shift of the mean frequency so that the change of wave-band is unsymmetrical. In Fig. 1 it is easily shown that

$$\omega_m = \omega_0\left(1 + \frac{3}{8}k^2\right).$$

Another point which is worthy of notice is that, whereas in Fig. 1 the charge to be given to the condensers to obtain a simple oscillation on simultaneous discharge was the same for both modes, in all the other cases one mode required the condensers to be charged to equal voltages and the other mode with equal quantities.

Separation of the Two Resonant Frequencies

In Fig. 1

$$\frac{\omega_2 - \omega_1}{\omega_0} = \frac{k}{\sqrt{1 - k^2}} = \frac{M/\sqrt{L_1L_2}}{\sqrt{1 - M^2/(L_1L_2)}}$$

where ω_0 is the resonant frequency of either circuit alone. In the other types of filter, however, the resonant frequency of either circuit in the absence of the coupling element is not near the centre of the band and it is more reasonable to express the separation of the two resonant frequencies as a fraction of their arithmetical mean ω_m. If this is done for Fig. 1 we obtain

$$\frac{\omega_2 - \omega_1}{\omega_m} = k\left(1 + \frac{k^2}{4}\right)$$

whereas $$\frac{\omega_2 - \omega_1}{\omega_0} = k\left(1 + \frac{5}{8}k^2\right).$$

It can also be shown that

$$k = \frac{\omega_2^2 - \omega_1^2}{\omega_2^2 + \omega_1^2}$$

a formula which enables us to calculate the coupling coefficient for any filter from the two resonant frequencies.

By substituting the values found above for ω_1 and ω_2 we obtain

for Fig. 2 $$\frac{\omega_2 - \omega_1}{\omega_m} = \frac{1}{2}\frac{A}{\sqrt{1 + A}}$$

where $$A = M'\frac{L_1' + L_2'}{L_1'L_2'} = \frac{M_1'}{L_{12}'}$$

and L_{12}' is the inductance of L_1' and L_2' in parallel.

For Fig. 3 $$\frac{\omega_2 - \omega_1}{\omega_m} = \frac{1}{2}\frac{B}{\sqrt{1 + B}}$$

where $$B = \frac{C_1' + C_2'}{C_3} = \frac{C_{12}'}{C_3}$$

and C_{12}' is the capacitance of C_1' and C_2' in parallel.

For Fig. 4 $$\frac{\omega_2 - \omega_1}{\omega_m} = \frac{1}{2}\frac{D}{\sqrt{1+D}}$$

where $$D = K_3\frac{K_1 + K_2}{K_1 K_2} = \frac{K_3}{K_{12}}$$

and K_{12} is the capacitance of K_1 and K_2 in series.

It is probably better, however, to take as the reference frequency neither f_o nor f_m but the quotient of the mean square divided by the mean since

$$\frac{\omega_2 - \omega_1}{\left(\frac{\omega_2^2 + \omega_1^2}{\omega_2 + \omega_1}\right)} = \frac{\omega_2^2 - \omega_1^2}{\omega_2^2 + \omega_1^2} = k.$$

Hence the ratio of the separation to this reference frequency is always equal to the coupling coefficient.

Although closely related this separation of the two resonant frequencies is not the same as the separation of the two humps which appear in the resonance curve when the coupling exceeds a certain value, nor is it a measure of the width of the band transmitted by the filter. For the calculation of these operating characteristics the method of approach adopted here is inferior to the direct application of circuit theory adopted in the various articles to which reference is given and to which we intend to refer more fully in a subsequent number.

G. W. O. H.

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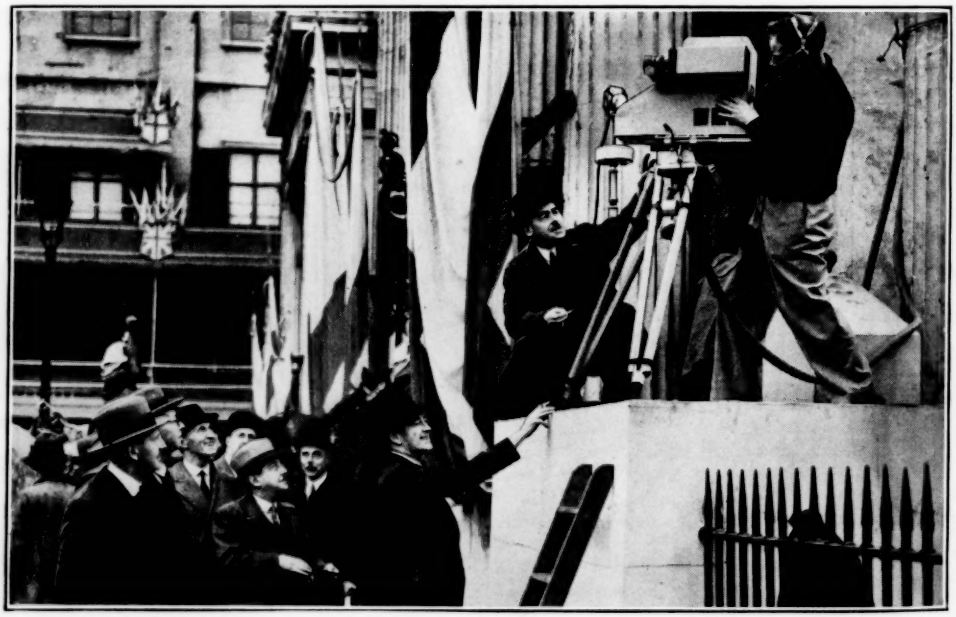

The Television Advisory Committee visited the site at Apsley Gate, Hyde Park Corner, where the television cameras were installed for the televising of the Coronation Procession. In this photo, Sir Noel Ashbridge, Chief Engineer of the B.B.C., is seen explaining details of the emitron camera to Lord Selsdon, Chairman of the Committee.

Audio-Frequency Transformers*

By E. T. Wrathall, A.C.G.I., A.M.I.E.E.

THE object of this article is to review the principles of audio frequency transformers, to apply these principles to simple and practical methods of design, and finally to describe the essential tests which should be applied to a finished transformer. It is desired that the paper shall be as short as possible; therefore transformers for ultra-audio frequencies will not be discussed, but it is hoped that from the description given of A.F. transformers and their associated circuits, it will be possible for the reader to apply the principles to the study of transformers for higher frequencies when desired.

The article is divided into the following sections:—

1. Introduction.
2. Nomenclature.
3. Equivalent circuits.
4. The ideal transformer and approximations to the ideal.
5. Transformers and associated circuits.
6. Design.
7. Testing.
8. List of references.

1. Introduction

Although the A.F. transformer is electrically the same as the ordinary power transformer, it is necessary to analyse its operation in a different manner because of the wide range of frequencies involved; and because it is most usually used as an impedance matching device. It is seldom that the principle of impedance matching is followed in power work for the reason that although this gives maximum power in the load, the efficiency and voltage regulation are only 50 per cent. Temperature rise is a negligible factor in almost all A.F. transformers and the magnetic condition of the iron is very different from that of the power transformer. In view of these considerations the A.F. transformer is best studied and designed on the basis of its equivalent network which is described in Section 3.

* MS. accepted by the Editor, June, 1936.

2. Nomenclature

Z_1, Z_2 —Terminating impedances of a transformer.

Z_p, Z_s —Impedance of primary and secondary windings respectively.

Z_m —Mutual impedance between transformer windings.

Z'_p —$K_z \cdot Z_p$, used in equivalent unity ratio circuit.

Z'_s —$K_z \cdot Z_s$, used in equivalent unity ratio circuit.

Z'_m —$\sqrt{K_z} \cdot Z_m$, used in equivalent unity ratio circuit.

Z_A, Z_B, Z_{se}—Impedances in series arm of equivalent T network; for convenience, three symbols are used in this case.

Z_c, Z_{sh}—Impedance of shunt arm of equivalent T network; for convenience, two symbols are used in this case. Z_{se} and Z_{sh} are used in connection with the application of Fig. 17.

Z_a, Z_b —Impedances in series arm of equivalent circuit of equivalent unity ratio transformer.

Z_c —Impedance of shunt arm of equivalent circuit of equivalent unity ratio transformer.

Z —Impedance.

L_p, L_s —Inductance of primary and secondary windings respectively.

l_p, l_s —Leakage inductance of primary and secondary windings respectively.

l —Leakage inductance consisting of l_p and l_s combined and referred to one side of a transformer, the high or low side being indicated in the text.

R_p —D.C. resistance of primary winding.

R_s —D.C. resistance of secondary winding.

R —D.C. resistance consisting of R_p and R_s combined and referred to one side of a transformer, the high or low side being indicated in the text.

M —Mutual inductance between primary and secondary windings.
M' —Mutual inductance in equivalent unity ratio circuit.
T_p, T_s —Numbers of turns in primary and secondary windings respectively.
K_1 —A complex factor governing the impedance looking into one winding of a transformer, the other winding being loaded.
K_2 —Coupling factor between primary and secondary windings.
K_z —Impedance ratio of transformer.
H Henry.
f Frequency p.p.s.
f_r —Resonant frequency p.p.s.
ω —$2\pi \times f$
ω_r —$2\pi \times f_r$
Q —Ratio of reactance to effective resistance of a winding; this ratio is a function of f.
X_p, X_s —Reactance of primary and secondary windings respectively.

3. Equivalent Circuits

In this connection it is necessary to define the impedance ratio K_z, which is one of the most important constants; it is defined as follows: the impedance ratio is the ratio of the terminating impedances into which a transformer is designed to be connected. It is desired at this point to stress that in a practical transformer it is only for two *particular* impedances of the correct ratio that the desired characteristic and efficiency are obtained; for all other values of impedance, even though their ratio be correct, the characteristic departs to a greater or less extent from that which is desired.

Consider the case of a transformer connecting an impedance Z_1 to an impedance Z_2, as shown in Fig. 1 (a); an e.m.f. "e" is acting in Z_1. Let T_p and T_s be the numbers of turns in the primary and secondary windings respectively; then in the design of a transformer $\frac{T_p^2}{T_s^2}$ is made equal to $\frac{Z_1}{Z_2}$.

It can then be proved that the impedance Z_2 viewed through the transformer from the primary side is $K_1 Z_2 \frac{T_p^2}{T_s^2}$; where K_1 is a factor dependent on the transformer constants Z_p, Z_s, and Z_m, which modifies the impedance both in magnitude and phase angle. The value of K_1 can be made to approach very nearly the value $1\angle 0°$ by careful design, which value holds for an ideal transformer. In the case of the ideal transformer then, it will be seen that the effect of the transformer is to load the

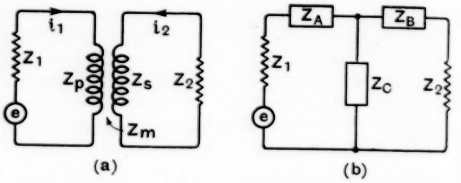

Fig. 1.—*Transformer Circuits.* (*a*) *Actual circuit;* (*b*) *Equivalent circuit.*

impedance Z_1 by an equal impedance to Z_1, namely $Z_2\left(\frac{T_p^2}{T_s^2}\right)$, which is the required condition for maximum output. The transformer is therefore acting as an impedance matching device and it is in this way that transformers will be considered; the process of design of practical transformers being to make this matching as perfect as possible, namely, to make the factor K_1, as nearly as possible equal to $1\angle 0°$.

In Fig. 1 (a) the impedances of the primary and secondary windings are represented by Z_p, and Z_s respectively; and Z_m is the mutual impedance between the windings: the coupled circuits of Fig. 1 (a) may be replaced by an equivalent network consisting of non-coupled elements as shown in Fig. 1 (b). The equivalent circuit shown is a T network of three elements Z_A, Z_B, Z_C, the values of which for a unity ratio transformer are determined by the equations (1) below.

$$\left.\begin{aligned} Z_A &= Z_p - Z_m \\ Z_B &= Z_s - Z_m \\ C_C &= Z_m \end{aligned}\right\} \text{ for a unity ratio transformer } \ldots \quad (1)$$

A π network could have been chosen to represent the transformer of Fig. 1 (a), but in general the T network is the more convenient and it will be found greatly to simplify transformer calculations and problems.

General Case of Non-unity Ratio Transformer.

Since the transformer is an impedance matching device, it is convenient for the purposes of analysis and design to consider

either the high impedance side only, or the low impedance side only ; these usually being referred to briefly as the " high " or " low " sides respectively. In each case, a simple transformation gives the required information for the other side. This may be made clearer perhaps by reference to Fig. 2 (a), since the impedance looking in the direction of the arrow " a " will be made as nearly as possible equal to Z_1, a design for a unity ratio transformer to suit terminating impedances of Z_1 would give the constants for the primary winding, and these would then have to be modified according to the impedance ratio in order to evaluate the constants of the other winding. What will be considered in the Design Section is the equivalent network of the equivalent unity ratio transformer.

Referring again to the non-unity ratio transformer of Fig. 2 (a), the impedance ratio is $\frac{Z_1}{Z_2} = K_z$; Z_s, Z_p and Z_m are the transformer constants. It can be shown that $Z_m = \sqrt{Z_p Z_s}$, in the absence of magnetic leakage.

The equivalent unity ratio circuit is shown in Fig. 2 (b), in which Z_2 is replaced by $K_z \,.\, Z_2$ (hence equal to Z_1) and the secondary

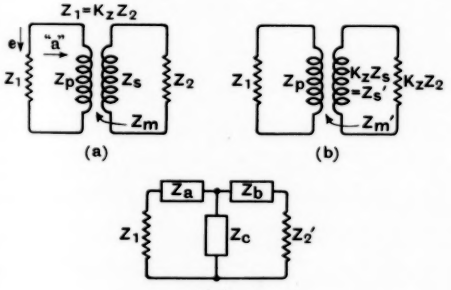

Fig. 2.—*Development of Equivalent Circuits. (a) Actual circuit ; (b) Equivalent unity ratio circuit ; (c) Equivalent of equivalent unity ratio circuit.*

winding impedance is made $K_z \,.\, Z_s$ (which may be called Z'_s). In the circuit of Fig. 2 (b),

$$Z'_m = \sqrt{Z_p Z'_s} = \sqrt{Z_p . K_z . Z_s} = \sqrt{K_z} . Z_m \quad .. \quad (2)$$

i.e. $Z'_m = \sqrt{K_z} \,.\, Z_m$.

Hence, neglecting leakage, a working approximation to the mutual impedance of the equivalent unity ratio transformer is given by

$\sqrt{\text{Impedance Ratio}} \times Z_m$ of actual transformer.

In order to realise what this conversion means it will be useful to refer to the example shown in Fig. 4 (a) and assume that the winding and mutual impedances are pure reactances and the coupling factor to be

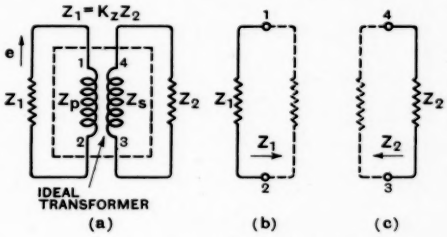

Fig. 3.—*The ideal transformer.*

unity. The coupling factor, K_2, is defined as :—

$$K_2^2 = \frac{M^2}{L_p L_s} \quad .. \quad .. \quad .. \quad (3)$$

where L_p and L_s are the winding inductances and M is the mutual inductance between them.

If K_2 is unity, equation (3) gives for Fig. 4 (a),

$$M = \sqrt{L_p L_s} = \sqrt{3.3 \times 1.1} = 1.9 \; H.$$

Whereas if the equivalent unity ratio circuit of Fig. 4 (a) is considered (it will be of the form given by Fig. 2 (b)),

$$M' = \sqrt{K_z} M = \sqrt{3} \times 1.9 = 3.3 \; H.$$

Had the equivalent unity ratio circuit been based on the low side, M' would have been 1.1 H.

The fact that in the equivalent unity ratio circuit the mutual inductance is equal to either the primary or secondary winding inductance, according to which of the terminating impedances is considered, is very important, and leads to a great simplification in treatment.

Equivalent Circuit of Equivalent Unity Ratio Transformer.

It is now required to find the values of non-coupled elements which may be used to simulate the coupled elements of Fig. 2 (b). The required network is shown in Fig.

2 (c) in which the series impedances are designated Z_a and Z_b, and the shunt impedance as Z_c. The values of the elements of Fig. 2 (c) may be written down by using equations (1) and (2).

$$Z_a = Z_p - Z'_m = Z_p - \sqrt{K_z} \cdot Z_m$$
$$Z_b = Z_s - Z'_m = Z_s - \sqrt{K_z} \cdot Z_m$$
$$Z_c = Z'_m = \sqrt{K_z} \cdot Z_m$$

where Z_p, Z_s, and Z_m are constants of the *actual* transformer.

4. The Ideal Transformer and Approximations to the Ideal

An ideal transformer is one in which there are no losses, which gives perfect impedance matching, and therefore causes no reflections when placed in circuit. Fig. 3 (a) shows an ideal transformer connecting two impedances Z_1 and Z_2 ($Z_2 > Z_1$); it follows from the definition of an ideal transformer that the impedance looking into its primary winding (1 — 2) will exactly equal Z_1 as shown in Fig. 3 (b); or, the impedance looking into the secondary winding will exactly equal Z_2. Although the current in Z_2 will be less than that in Z_1, the voltage across it will be greater and will be of such a value that the power dissipated in Z_2 is equal to that dissipated in Z_1. The secondary voltage and current are coupled to the primary circuit through the mutual impedance in such a manner that the impedance Z_1 is loaded by an equal impedance, which is the condition essential for maximum power transference.

In order that an ideal transformer shall cause zero loss, it follows that its primary, secondary, and mutual impedances must be infinity, and of course the windings must have no resistance. In the equivalent circuit of Fig. 2 (c) it follows that Z_a and Z_b must be zero, and Z_c must be infinity.

In order to see how nearly an actual transformer approaches the ideal from the point of view of impedance matching, it is convenient to consider the example shown in Fig. 4 (a); it will become evident that even a medium quality transformer provides quite a good degree of matching. The example chosen is that of a transformer intended to couple two resistive lines, one of 1 800 ohms and the other of 600 ohms. The transformer is intended to cover the commercial speech range of frequencies, namely, from 275 p.p.s. to 2 750 p.p.s. and has a loss of about 1 db. at 200 p.p.s. The constants of the windings are shown in Fig. 4 (a); the circuit can be represented by that of Fig. 4 (b) in which the mutual impedance Z_m, the leakage inductances l_p and l_s, and the D.C. resistances R_p and R_s of the windings are shown. Alternatively the circuit may be simplified still further as shown in Fig. 4 (c), which is the equfvalent of the equivalent unity ratio transiormer: in this case, Z_p equals the primary winding impedance; R_p and R_s have been combined into R, and l_p and l_s have been combined into l. This is a close approximation to the actual conditions and it will be clear that Z (looking in the direction of the arrow) consists of $Z_1 + R + l$ in series, all shunted by Z_p.

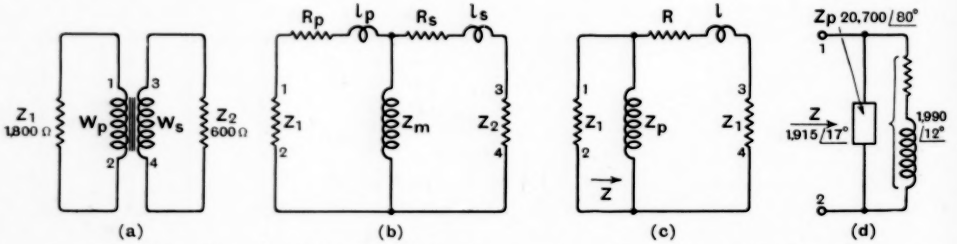

Fig. 4.—*Comparison of actual with ideal transformer. Transformer details in* (a). $L_p = 3.3$ *H*, $R_p = 85\Omega$, $T_p = 1585$ *turns*, $L_s = 1.1$ *H*, $R_s = 23\Omega$, $T_s = 916$ *turns. Coupling factor* = 0.98.

Transformer Data.

$$R = R_p + K_z \cdot R_s = 85 + 69 \text{ ohms}$$
$$= 154 \text{ ohms.}$$

The value of l is the value of the inductance measured on the primary side with the secondary winding short-circuited. As the coupling factor is 0.98 (or 98 per cent.) the

value of l is 2 per cent. of L_p, which in this case is 0.066 H. The defining of l as a percentage of L_p is very convenient and will be used later, in the Design Section.

It will be seen that the impedance Z is

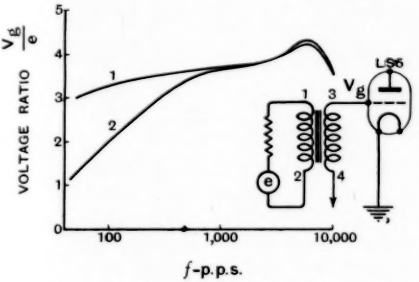

Fig. 5.—*Effect of direct current on characteristic of transformer. Curve* 1, *No D.C. in winding* (1–2); *Curve* 2, 4 *mA D.C. in winding* (1–2).

the parallel impedance of the combination shown in Fig. 4 (d). The phase angle and magnitude of Z_p can be obtained from the Q value of the winding and its inductance; for this transformer at 1 000 p.p.s. $L_p = 3.3$ H, $Q = 5.3$ from which $Z_p = 20\,700 \angle 80°$. (Q is the tangent of the phase angle). The impedance of $R + l + K_z \cdot Z_2$ (the last term equals Z_1) is $1\,990 \angle 12°$. The parallel impedance of the combination will be found to be $1\,915 \angle 17°$ which is not very different from the value of $1\,800 \angle 0°$ which would be given by an ideal transformer.

In certain cases, for example, where a transformer terminates a filter, it is necessary for the impedance matching to be closer than this. This can be achieved by using a multiplying factor for the theoretical impedance ratio to allow for the effect of the transformer. The magnitude of the impedance Z looking into the high winding (Fig. 4 (d)) is 1 915 ohms, the ratio of this to the theoretical value is $\frac{1\,915}{1\,800} = 1.06$, hence if the circuit can be arranged so that the terminating impedance on the low side is $\frac{600}{1.06} = 565$ ohms, the impedance looking into the high winding will actually be 1 800 ohms, but with a phase angle of 17°. By suitable design and choice of materials, this factor can be made more nearly equal to unity and the phase angle reduced.

5. The Transformer and Associated Circuits

Care must always be taken to ensure that the effects on a transformer of the associated circuits are fully allowed for. The associated circuits may have a profound effect in two main ways; either by reason of direct current flowing through the circuit changing the transformer inductance, or the combined circuit and winding capacitances may largely affect the terminating impedance of the transformer; it is proposed to refer to one example illustrating the effect of direct current on the characteristic of a transformer and to consider two examples in which interest is centred in the effect of capacitance: the illustrations are based on measured curves.

Fig. 5 shows the characteristics of an input transformer connecting a 6 000 ohms impedance to a valve similar to an LS5, with and without D.C. in the windings; it will be seen that a current of only 4mA almost halves the voltage ratio at 70 p.p.s. but the effect on the characteristic from 1 000 p.p.s. upwards is negligible.

The effect of associated capacitance is shown in Figs. 6 and 7. Fig. 6 shows the characteristic of an input transformer connecting a 60 ohms impedance to an LS5 type of valve. Curve (a) is the characteristic

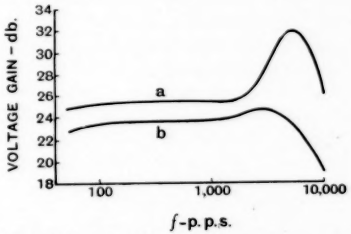

Fig. 6.—*Effect of shunting secondary winding with a resistance to reduce resonance peak.* (*a*) *Transformer working directly into grid;* (*b*) *Transformer secondary shunted by* $10^5\Omega$.

when the transformer is connected directly into the grid circuit; in this case, the valve capacitance combined with the transformer capacitance causes a marked resonance at about 6 000 p.p.s. followed by a sharp decline in response. Curve (b) shows the effect of shunting the transformer secondary winding with a resistance of 100 000 ohms; the voltage gain is slightly reduced but the peak is made negligible and the response is quite good.

In *The Wireless Engineer* of August 1928 Hartshorn gives a simple formula for calculating the effective grid-filament capacitance of a valve with a resistive plate circuit load.

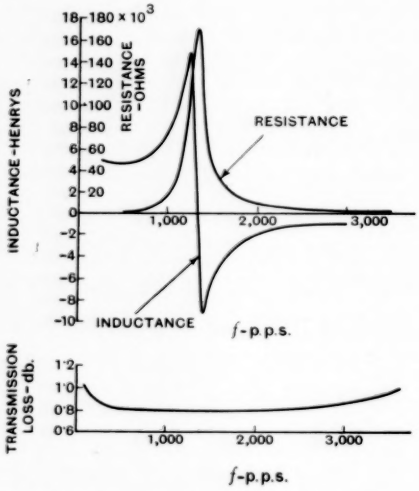

Fig. 7.—*Example in which resonance in windings is unimportant.*

Let R_a = Valve differential resistance
R = Anode load resistance
μ = Magnification factor of valve
C_{gf} = Geometrical grid-filament capacitance of valve
C_{ga} = Geometrical anode-filament capacitance of valve
C'_{gf} = Effective grid-filament capacitance of valve

then, $C'_{gf} = C_{gf} + C_{ga}\left(1 + \frac{\mu R_a}{R + R_a}\right)$.

The subject is also treated in *The Bell System Technical Journal* of April 1924.

It is rather important to notice how a transformer may be connected so that the bad effects due to its self-capacitance may be made a minimum. For example, Figs. 8 (a) and 8 (b) show wrong and correct methods of connecting a push-pull transformer in a valve amplifier; it will be seen that the correct method gives a symmetrical distribution of associated capacitances. Fig. 9 (a) illustrates how incorrect connection of an ordinary input transformer may cause a reduction in gain at the higher frequencies because of the low impedance path offered by the inter-winding capacitance; this

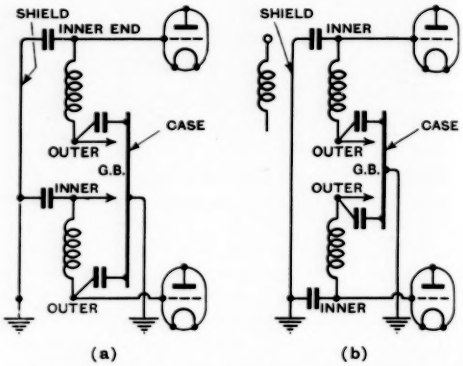

Fig. 8.—*Methods of connecting a push-pull transformer. (a) Incorrect; (b) Correct.*

trouble is reduced if the connections of Fig. 9 (b) are used.

Fig. 7 illustrates the case of a transformer connecting two lines each of 600 ohms resistance. It will be seen that the inductance and capacitance of one of the windings undergo parallel resonance at about 1 400 p.p.s., but although after resonance the winding acts as a capacitance, the shunt impedance of the equivalent circuit is so high that its change in character has no effect on the frequency characteristic.

Transformers are mostly used in the Class A condition of amplification; in a Class B stage the effect of grid current on the transformer is negligible because, being a push-pull arrangement, the grid currents in each half of the secondary counteract

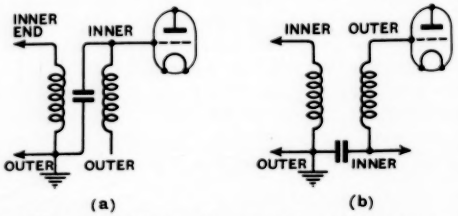

Fig. 9.—*Methods of connecting an input transformer. (b) is the better method.*

each other. A more important effect occurs on the bias of the valves due to the voltage change across the grid resistances causing the bias to fluctuate; this effect is minimised by using grid resistances of low value: incidentally this reduces the bad effects of associated capacitances as well.

(To be continued.)

Frequency Measurement*

A New Equipment for the Range 1—70 Mc/s

By H. A. Thomas, D.Sc., A.M.I.E.E.

(Radio Department National Physical Laboratory)

1. Introduction

THE measurement of frequency is of fundamental importance in the development and testing of radio apparatus. The accuracy with which frequency measurements can be made is now of the order of a few parts in ten million and such measurements can be used to form the basis of determinations of other electrical quantities such as inductance and capacitance.

There are at present a number of commercially produced equipments for measuring frequency, embodying one or more multi-vibrators controlled by quartz-crystal oscillators. One of these, for example, covers the range 150–30,000 kc/s and is controlled by a 1,000 kc/s source. Another has a frequency range of 1–10,000 kc/s and is controlled by a 50 kc/s source and a third has a range of 1–30,000 kc/s controlled by a 50 kc/s source. All these equipments make use of devices which mix the harmonic frequencies generated by the several multi-vibrators.

At the National Physical Laboratory, the primary standard of frequency is a 1 kc/s tuning fork of which the accuracy over short periods is of the order of 5 parts in 10^8 and over long periods of the order of 3 parts in 10^7†. This standard source being available, it was obviously desirable to make use of it and consequently the design of the equipment differs appreciably from that of the quartz-controlled apparatus previously mentioned. There are at present two frequency-measuring equipments known to the author which are based on a 1 kc/s source. There is the multi-vibrator designed by Dye and known as the N.P.L. Type, the frequency range of which is 10–1,200 kc/s and the equipment used by the Radio Branch of the Post Office Research Station, covering the frequency range 1,000–25,000 kc/s.†

In designing the present equipment for the Radio Department of the Laboratory, attention was directed to the ease of operation as well as the accuracy of measurement. It was necessary to increase the range to 70 Mc/s and experience had shown the desirability of using dependable scales to eliminate calibration charts at the higher frequencies. In view of the upper frequency limitation of the original N.P.L. type of multi-vibrator, it was considered advisable to explore the possibility of using a system similar in essential principles to that of the Post Office. Accordingly, preliminary experiments were made from which it was ascertained that this scheme of obtaining fixed frequencies related to the fundamental fork frequency was suitable for the higher frequencies required. The special features of the new equipment are consequently mostly confined to improvements in the operation of the instrument whereby accuracy may be obtained without the use of calibration charts and with a minimum of cross-checking.

2. Principle of Operation

The general scheme of design follows that of the Post Office frequency-measuring equipment. For the sake of completeness, the basic principles of this instrument are re-stated.

Referring to Fig. 1 which shows the sequence of the various stages in schematic form, it is seen that an e.m.f. of about one volt at 1 kc/s derived from a standard fork controls an oscillator at the same frequency. The output from this oscillator is filtered

* MS. accepted by the Editor, January, 1937.

† "The Valve-Maintained Tuning Fork as a Primary Standard of Frequency." D. W. Dye and L. Essen. *Proc. Roy. Soc.*, A, 143, 1934, pp. 285–306.

† "Crystal Oscillators for Radio Frequencies—An Account of Experimental Work carried out by the Post Office." O. F. Booth and E. J. C. Dixon. *J.I.E.E.*, 1935, 77, pp. 197–244.

and amplified and is used to control a 1 kc/s multi-vibrator. This filtering system and locked 1 kc/s oscillator would be unnecessary if the master fork were situated in close proximity to the multi-vibrator, but in this particular case the fork voltage is supplied by a long line which picks up a great deal of extraneous interference from machines and mains, and consequently it was necessary to purify the locking signal.

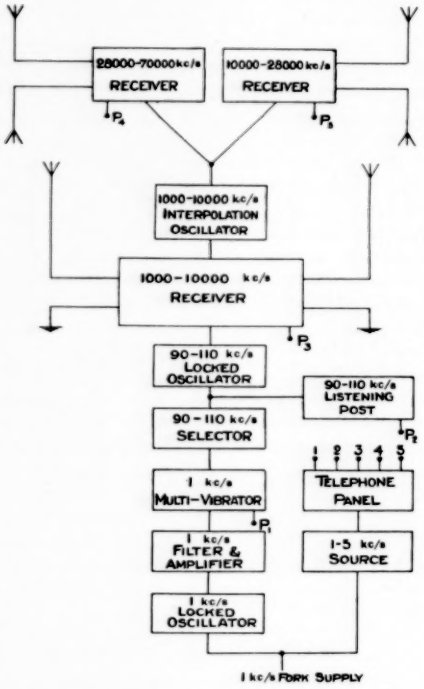

Fig. 1.—*Schematic diagram of frequency measuring equipment.*

The output from this multi-vibrator is filtered to reduce the amplitude of the lower harmonics and a flatly tuned acceptor circuit is provided to amplify all the harmonics within the frequency range 90–110 kc/s. Any particular harmonic within this frequency band is selected and used to control the frequency of an oscillator which can be adjusted within the same 90–110 kc/s range. A listening post is provided at this point by which means the setting of the oscillator and selector can be adjusted to eliminate 1 kc/s modulation. With a little care in setting these circuits, the output from the 90–110 kc/s locked oscillator can be made free of adjacent harmonic frequencies, which condition is detected by the absence of a 1 kc/s note in the listening post detector circuit.

The output signal from the locked oscillator is distorted by an over-biased rectifier, and harmonics between the 10th and 100th are selected in the 1,000–10,000 kc/s receiver. An interpolation oscillator covering the same frequency range as the receiver is very loosely coupled to the input of the receiver and gives a heterodyne beat note with the selected harmonic of the locked oscillator frequency. By means of the interpolation condenser, the frequency of this oscillator can be adjusted to the selected harmonic. By this method of producing known harmonic frequencies, it is possible to obtain a point calibration of the oscillator over the frequency range 1,000–10,000 kc/s, and by selecting the frequency of the 90–110 kc/s locked oscillator, it is possible to obtain a calibrated frequency within $\pm$ 10 kc/s of any unknown frequency within this range. In addition to the large number of fixed-frequency calibrating points, further fixed points are provided in the following manner. The fork signal at a frequency of 1 kc/s is used to generate the audio-frequencies 1, 2, 3, 4 and 5 kc/s. A signal at any of these frequencies can be put in series with the receiver telephones and by this means beats can be obtained when the interpolation oscillator frequency is 1, 2, 3, 4 or 5 kc/s above or below any selected fixed harmonic frequency.

The process of measurement is therefore one in which the frequency of the interpolation oscillator is set to two known harmonic frequencies 1 kc/s apart and then to the unknown frequency which lies between them, the latter being determined by interpolation. The accuracy of this method of measurement is better than 5 parts in a million and can be increased by the use of an audio-frequency meter or a beat counter.

For the measurement of frequencies within the range 10,000–70,000 kc/s two short-wave receivers are provided with di-pole aerial systems. The signal of unknown frequency

is received by one of these receivers and is heterodyned by a suitable low harmonic of the interpolation oscillator, the fundamental frequency of which is in turn measured in the usual manner. The coupling to the oscillator is so weak that no change of frequency occurs as the tuning of the short-wave receiver is varied. By means of a telephone switching panel the listening telephones can be connected to the various stages of the apparatus for checking the conditions at each point.

One considerable advantage of this method of obtaining fixed harmonic frequencies is the readiness with which self-checking can be utilised. Many of the fixed frequency points may be derived in more than one way. For instance, the frequency 8,820 kc/s is the 84th harmonic of 105 kc/s, the 90th harmonic of 98 kc/s or the 98th harmonic of 90 kc/s. Consequently, if the 90–110 kc/s locked oscillator is set to 105, 98 and 90 kc/s successively, the beat note between the interpolation oscillator output and the received harmonic at 8,820 kc/s should remain unchanged if the receiver is tuned correctly. This is a simple means of checking a number of fixed points on the receiver scale, though in practice it is found that the scale calibration remains sufficiently constant to dispense with this procedure except on rare occasions when large temperature changes have occurred and there is doubt as to the true setting of the receiver scale.

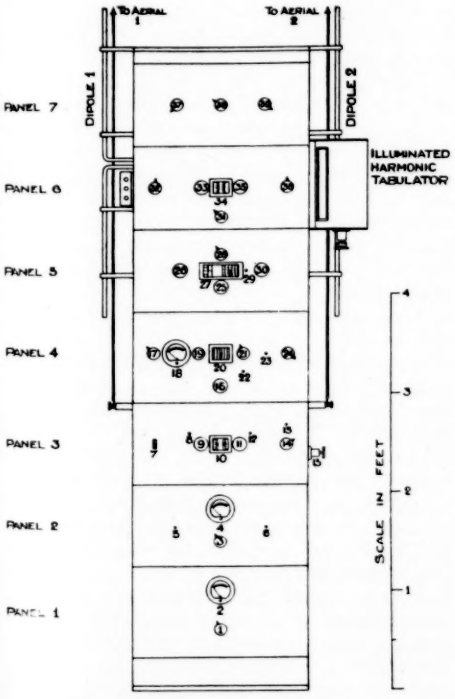

Fig. 2.—*Layout of the apparatus.*

Although the apparatus is reasonably simple to use and the control of the 1 kc/s multi-vibrator and of the locked oscillator is such that synchronism with the selected harmonic frequency is maintained over a period of many hours without adjustment, the operation is much facilitated by the employment of reliable scales and an easily read interpolating oscillator condenser. Consequently considerable attention has been devoted to making the operation as reliable and simple as possible with the object of eliminating calibrating uncertainties and the use of calibrating charts. The means adopted to obtain these characteristics are described in the following section dealing with the constructional details.

3. Constructional Details

(a) General Lay-out of Panels.

The lay-out of the various parts of the apparatus is shown in Fig. 2. The components of each panel are mounted on a horizontal aluminium base plate fixed to a vertical panel which is mounted four inches behind the actual front panels. A screening box slides over each compartment from the back and is clamped into position by four self-locating screws with easily controlled knobs so that any panel can be inspected without dismantling any other part. The mechanical controls, scales, etc., are mounted between the two front vertical panels, thus separating the electrical and mechanical parts of the apparatus. Each front panel can be removed without disconnecting any electrical connections by unscrewing the various control knobs on the particular panel. All valves are mounted at the back of the horizontal panels for accessibility and each anode circuit is provided with a jack so that

testing for faults is facilitated. The whole set of panels is mounted on a standard Post Office rack, 20½in. wide, the total height and depth of the equipment being 6ft. 6in. and 1ft. 8in. respectively.

The lowest panel referred to as No. 1, contains the power supply controls. The common H.T. supply to all valves is 150 volts and the total current 130 milliamperes. This is obtained from a 110 volt 50 cycle A.C. supply by a double-wave valve rectifier; the D.C. voltage is smoothed in the conventional manner and stabilised by neon-filled valves; a common grid bias line of — 20 volts is also provided by the same power supply unit. It was found advisable to use a battery supply for filament heating to obtain clean heterodyne notes, since trickle charging was found to produce too much mains noise and indirectly heated A.C. valves gave instabilities of a serious nature. A main switch 1 and H.T. voltmeter 2 are provided on the front panel, the switch operating on all three supply circuits at the same time.

Panel 2 carried the controls of the locked 1 kc/s oscillator, filter system and 1 kc/s multi-vibrator. The tuning of the oscillator and multi-vibrator is adjustable by the pre-set controls 5 and 6 respectively, which can only be altered by a special adjustment. The controls of the 90–110 kc/s selector and locked oscillator are mounted on Panel 3, the tuning scales and slow-motion knobs being represented by 10, 11 and 9 respectively; the pre-set adjusting condensers for these circuits are 12 and 8. The selectivity of the selector system is controlled by the knob 14 and a pre-set adjustment 13; correct adjustment can be obtained by noting the deflection of the rectifier instrument 4 when the oscillator is switched off by 3; when any particular harmonic is correctly selected, this rectifier instrument reads a minimum current. This same instrument 4 can be connected to the anode circuit of the selector system by the key switch 7 and in this position shows the maximum selectivity which can be obtained before self-oscillation commences.

The controls of the 1,000–10,000 kc/s receiver are on panel 4. Tuning is effected by the slow-motion knob 15; the six frequency ranges are changed by the knob 19 operating the coil switch together with the pointer on the scale 20, and the selectivity is controlled by the knob 21. A pre-set adjustment 22 enables the scale setting to be corrected for temperature change of the oscillation circuit and the anode current meter 18 enables the operator to note when oscillation takes place and also serves as an indicator of the correct tuning to any selected harmonic or outside signal. A volume control 24 is provided and also a pre-set coupling adjustment 23 to the interpolation oscillator. The switch 17 changes the input connections from the harmonic selector to the aerial 1 for receiving an outside signal. With this switch in the "selector" position, a second aerial 2 can be connected to the receiver by the switch 15, and in this position direct beating can be obtained between any outside signal and a locked selected frequency. By the use of a frequency-measuring instrument in the telephone circuit, frequency variations over a small range can be observed without using the interpolation oscillator. This addition is very useful for many applications of the equipment, such as frequency-drift measurements on oscillators.

Panel 5 carries the controls of the interpolation oscillator. A six-range switch 30 is provided and the slow-motion knob 25 operates the frequency-divided scale 27. The calibration can be adjusted by the pre-set control 29 and the oscillator can be switched off by the mercury switch 28. The special interpolating condenser is operated by the knob 26, the setting being read off directly on the scale 27.

The two short-wave receivers covering the frequency ranges 10,000–28,000 and 28,000–70,000 kc/s are situated above the interpolating oscillator, the controls being mounted on panel 6. The frequency setting is adjusted by the knobs 33 and 35 and read off on the scales 34, while the selectivity is controllable by the knobs 32 and 36. The coupling to the interpolation oscillator is changed by the switch 31 and the two pairs of di-poles are mounted on each side of the frame as shown.

Lastly, panel 7 comprises the telephone switching system 37 and the audio beat frequency selector system; the beat frequency amplitude is controlled by the knob 38 and the required beating harmonic can be selected by the knob 39. Three telephone

plugs are provided on the left of the panels and an illuminated harmonic tabulator is situated on the right of the set. This tabulator gives a list of all the fixed frequencies which can be derived within the range 1,000–10,000 kc/s and dispenses with the use of calibration charts.

(*b*) *Design of Condenser Scales.*

As previously mentioned, the ease of operation is largely dependent on the accuracy and dependability of the calibration of the various frequency scales. With the object of obtaining a higher accuracy than can be got by the use of conventional dials

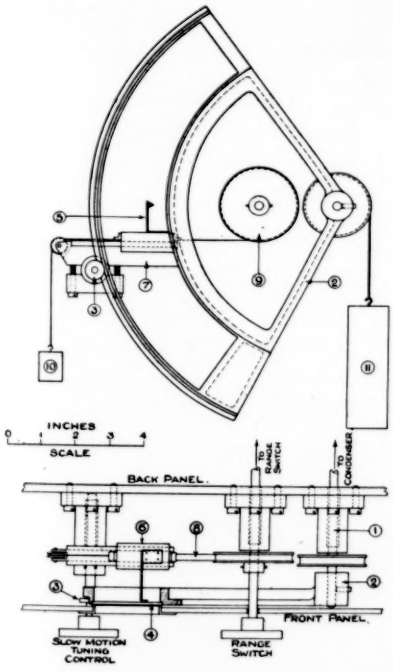

Fig. 3.—*Example of dial slow motion control with scale and range switch.*

and pointers, special illuminated scales have been used throughout and also each tuned system has been carefully enclosed in thermally-lagged screened cases to prevent any sudden changes of temperature.

The arrangement of the interpolation oscillator scale and range switch serves as a convenient example of the design of the other scales and is shown in Fig. 3. The earthed condenser spindle 1 is brought through the first of the two front panels and is provided with a special quadrantal drive arm 2 holding a glass scale 4. The out-of-balance weight is eliminated by a counter turning moment provided by the weight 11 and pulley. A slow-motion drive for the driving arm 2 is provided by the tuning knob and rubber-edged wheel 3 bearing on the outer circular arc of the arm.

The range switch which is connected to a spindle and control knob has six positions each of which is defined by means of a click wheel mounted on the switch rotor. A pulley 9 is fixed to this same operating spindle; this pulley is fixed to the steel ribbon 8 which in turn is fixed to the bracket 6 sliding on the fixed guide rail 7. By means of the cord and weight 10, the steel ribbon 8 is kept always in tension and as the pulley 9 is rotated by the range switch knob, the bracket 6 moves along the guide rail. This bracket carries a pointer 5 which traverses the graduations on a transparent glass scale 4 fixed to the condenser arm 2. By this means, the frequency setting is read off directly without the necessity of reference to the position of the range switch, which in fact has no pointer.

The scale markings were produced in the following manner. A plain frosted glass scale was clipped on to the arm 2 and the set was calibrated by harmonic selection. The calibrating points obtained in this manner were pencilled on the scale and then the glass plate was removed and the pencil marks transferred to an enlarged paper scale by graphical means. The complete scale was then drawn by interpolation and the kc/s values typed on to the scale. A glass scale of the original size was made photographically and the surface coated with a matt varnish to simulate frosting. This scale was then mounted on the drive arm in the same position as the original glass scale. By this means, the complete frequency range is covered by six scales on one glass slide, while the reading accuracy is high since, by using the shadow of the pointer 5, parallax is avoided, and by the use of such long scales uncertainty of setting is removed even at the highest frequency of 10,000 kc/s.

(c) The Interpolation Oscillator Condenser.

The interpolating accuracy of the oscillator is dependent on the linearity of the change of capacitance with setting of the fine tuning condenser dial, together with the discrimination of the scale. Considerable care must be taken to obtain a satisfactory linear relationship between the scale reading and the capacitance variation. The method adopted in the present case is illustrated by Fig. 4.

The main feature of the condenser is the use of a sliding piston working in a concentric cylinder; if the gap is small, the capacitance change is proportional to the axial motion of the piston over a large range. The piston 2 is made of hardened steel and is ground cylindrical, the bearing stems being machined at the same time as the piston surface. This piston slides in the close fitting bearings 7 and is prevented from turning by the pin and guide 9. The fixed cylindrical electrode 3 is clamped between circular insulating plates mounted in the main earthed casting which is electrically connected to the piston by the light metal strip 1. The piston is moved by a micrometer 12 acting through a steel ball 11 and glass disc 10, the latter being gummed to the piston stem to prevent the formation of an oxidising film between the steel ball and plunger.

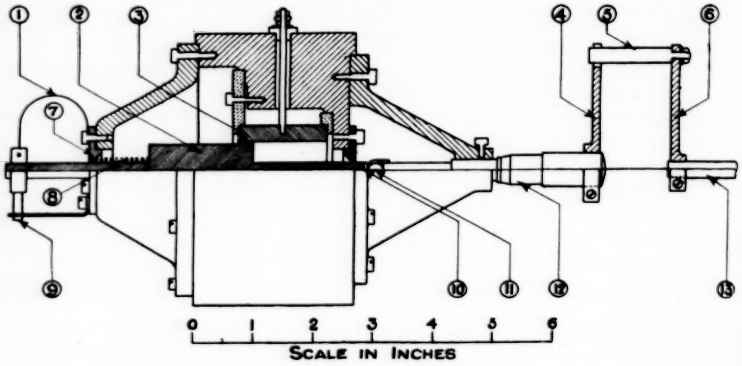

Fig. 4.—*Interpolating condenser.*

The micrometer head is rotated by a driving arm 4 and pin 5, the latter being rotated by the arm 6 fixed to the driving spindle 13. This spindle executes 40 complete revolutions for the total piston displacement of one inch corresponding to a capacitance change of about 2 $\mu\mu$F. The position of the piston is observed by a glass scale fixed to the spindle 13 and a secondary geared scale giving the number of complete turns from the end position. This geared scale has 40 divisions and the main scale 100 divisions so that the total capacitance change of 2 $\mu\mu$F. is divided into 4,000 parts, the accuracy of reading being about a quarter of a division. The geared and main scales are so arranged that the two numbers completely defining the piston position are seen side by side. Thus a scale change from 1085 to 1463 means that the arm 6 has executed 3.78 turns.

(d) Miscellaneous Constructional Details.

The condensers used for all the calibrated tuned circuits are of the series-gap type with the moving system earthed; the rotor and stator plates are made of heavy gauge brass to give a high degree of permanence. The coils are wound on grooved paxolin formers of cylindrical form and each complete oscillation circuit is enclosed in a thermally-lagged screening box.

The method of locking the 1 kc/s and the 90–110 kc/s oscillators is somewhat unusual. Tetrode valves are used for these circuits and the locking signal is applied to the screen grid.†. By a suitable adjustment of the screen potential, it is possible to get satisfactory locking with a weak signal and practically no trace of retro-active effect into the locking signal circuit. This is particularly valuable in the case of the 90–110 kc/s oscillator, since the selector circuit can be adjusted to exact resonance with any selected harmonic independently of the oscillator setting.

† "A Frequency-Lock Multi-Vider," J. A. de Young, *Q.S.T.*, 1935, *19*, Sept., pp. 32–33.

The various grid bias potentials are derived from the common 20 volt bias main by high resistance potential dividers, each circuit being provided with a de-coupling system to eliminate mutual interference. A similar system of de-coupling resistances is used for all the anode circuits and by such means complete independence of function is obtained in each stage of the assembly. A photograph (Fig. 5) shows the lay-out and general appearance of the complete equipment.

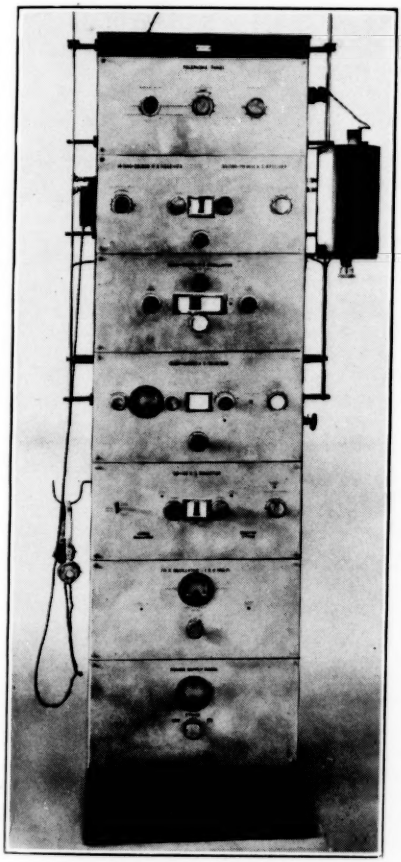

Fig. 5.

4. Operation

The chief operating advantage of this system of harmonic derivation is the purity of the output signal giving simple heterodyne beating with the interpolation oscillator. In Dye's original fork-controlled multivibrator, the radio-frequency output was modulated by the low-frequency source. This modulation gave rise to a large number of harmonic tones which were difficult to distinguish. By eliminating this modulation, the frequency difference between any selected harmonic and the oscillator output is observed without difficulty or ambiguity by the insertion of the available audio-frequency tones into the telephone circuit. A further practical advantage is the entire absence of calibrating charts. All frequency calibrations are directly marked on the various scales and the list of available harmonic frequencies is always readily observable by inspection of the illuminated harmonic tabulator.

The short-wave receivers are not only of great value in extending the frequency range, but are also useful when a signal within the 1,000–10,000 kc/s frequency range is subjected to interference. If a satisfactory beat note cannot be obtained when the signal is received in the normal manner, it is often possible to receive a harmonic of the wanted signal, free from interference, on one of the short-wave receivers and then to measure this signal frequency by a suitable harmonic derived from the interpolation oscillator output. This flexibility of operation is of great value in laboratory measurements since considerable interference is often present.

5. Acknowledgments

The equipment described in this paper was constructed for use in connection with work undertaken for the Radio Research Board of the Department of Scientific and Industrial Research. The author is indebted to the staff of the Radio Branch of the Post Office Research Station for helpful suggestions given in the early development work. The equipment was constructed entirely in the Radio Department of the National Physical Laboratory by Mr. F. G. Murfitt, and the author was assisted in the design and experimental work by Mr. A. C. Haxton.

Ground and Ionospheric Rays*

A Computation of the Relative Intensities on Various Wavelengths from Existing Data

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(Radio Dept., National Physical Laboratory)

ABSTRACT.—The paper constitutes an attempt to compute the relative intensities of the ground or direct ray and of the ionospheric ray. It is shown that it is not possible to calculate the intensity of the ionospheric ray theoretically on account of the incompleteness of our knowledge of the ionosphere. Such experimental data of the " reflection coefficient " of the ionosphere as is available has, however, been used to calculate the probable intensity of the ionospheric ray on several wavelengths and ranges up to about 1,000 km. under various conditions such as time of day, season of the year, etc. The intensity of the ground ray has been calculated from well-established formulae for the same wavelengths and ranges and for two ground conductivities corresponding to average soil, and sea water respectively. The results are given in the form of graphs for the special case of a transmitter radiating equally in all directions, vertically and horizontally. It is shown how the relative intensity of ground ray to ionospheric ray may be estimated for any transmitter whose vertical polar diagram is known. Finally the results are used to estimate the probable useful working ranges of loop direction-finders under conditions when both ground and ionospheric rays are present. For instance, on 1,000 metres, at night, the range of a loop direction-finder free from " night effect " would be about 40 km.

1. Introduction

IN radio communication the question of the relative intensities of the ground or direct ray and the ray which has travelled by way of the ionosphere is of importance in several respects. It is, for instance, of importance in broadcasting in determining the effective service area free from fading effects. It also determines the range within which direction-finding systems subject to polarisation errors (such as closed-loop systems) may be used with any prescribed degree of freedom from error due to this cause.

The present paper has been written mainly with a view to providing data which will enable the useful working range of loop direction-finders to be calculated. In a later section it will be shown from the data here given, and from a knowledge of the distribution of energy in a vertical plane through the transmitting aerial, how an estimate may be obtained of the relative intensities of the ground and ionospheric rays and hence of the range within which a loop direction-finder (or, indeed, any direction-finder whose polarisation error is known) may be used with freedom from this type of error.

* MS. accepted by the Editor, November, 1936.

2. Ground Ray

The calculation of the intensity of the ground ray at points on the surface of an imperfectly conducting spherical earth can be made by combining the results of Sommerfeld's analysis for a plane earth with Eckersley's modification of Watson's formula[1] for the diffraction of waves round a spherical earth. Sommerfeld's analysis[2] will hold at points near the transmitter while the diffraction formula applies to distant points. Curves have been drawn based on each of the two formulae and from these it is fairly easy to see at what point transition takes place from the Sommerfeld results to those of Eckersley-Watson. The resultant curve for ground ray intensity is then obtained by selecting and combining the appropriate sections of the Sommerfeld curve and the Eckersley curve. It is believed that in this way the ground ray intensity is obtained with high accuracy and this is the method which has been used for the computation of this quantity in this paper. Two ground

rays have been calculated, corresponding to soil of average conductivity and to sea water respectively.

3. Ionospheric Ray

The problem of the propagation of plane waves through an ionised medium in the presence of a magnetic field has received considerable attention, and the special case in which the properties of the medium (such as density of ionisation) do not change rapidly with wavelength has been formally solved by the well known Magneto-ionic Theory of Appleton, Hartree and Goldstein.[3] The solution, an extension of the Lorentz theory of propagation of waves in a dispersive medium, shows that the "refractive index" for the wave in the medium is complex, thus implying both refraction and absorption. The real part of the complex quantity here referred to is usually called simply the "refractive index" of the medium and the imaginary part, the absorption coefficient, designated "μ" and "k" respectively. Thus for complete knowledge of the absorption suffered by a wave traversing an ionised medium we require to know the value of "k" at all points along the path of the wave.

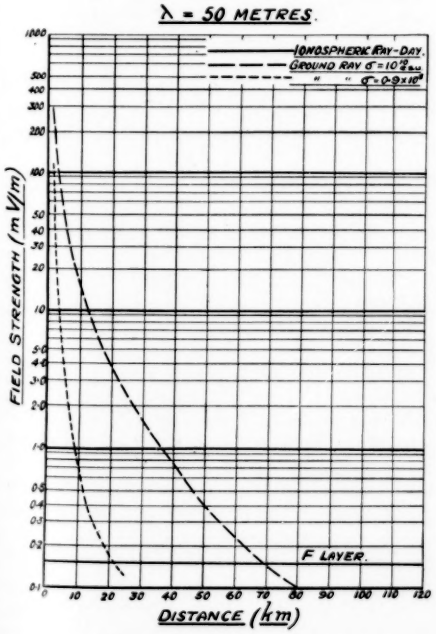

Fig. 1.

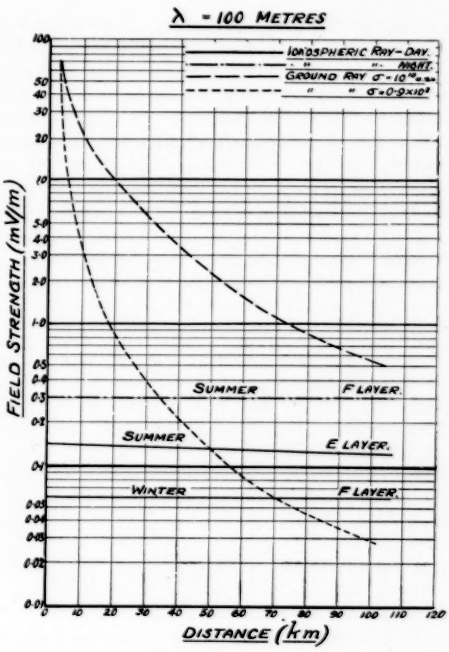

Fig. 2.

In the general case, the expressions for μ and k become extremely cumbersome, and are moreover, two-valued. This means that in general the ionosphere behaves as a doubly refracting medium, a plane wave being split into two "magneto-ionic" components having different states of polarisation, different refractive indices, and different coefficients of absorption. The quantities "k" and "μ" at any point in the ionosphere are functions of "N" the density of ionisation, "ν" the frequency of collision between electrons and molecules, and of the components of the earth's magnetic field along and perpendicular to the direction of propagation of the wave, at the point considered.

Were all these quantities known, the problem for plane waves could be solved, formally at all events. The integrals involved, however, are so extremely complicated that, except by use of methods of approximation, the solution could not be completed.

The extension of these results to spherical waves could then be made to a first approximation by assuming for instance that the factor taking account of absorption was the same for spherical waves as for plane waves. This factor is usually referred to, rather loosely, as the " reflection coefficient " of the ionosphere, this being defined as the ratio of the intensity of the reflected wave which actually obtains in practice to the intensity which would obtain if the ionosphere behaved as a perfect reflector.

4. Structure of the Ionosphere

By various methods, the complicated stratified structure of the ionosphere has been examined, and it has been shown that two well-defined regions of high ionisation

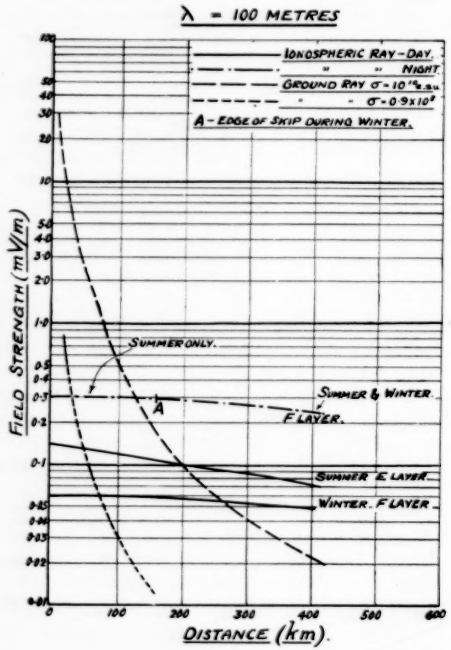

Fig. 3.

exist called the E and F layers at heights of about 110 km. and 200–300 km. respectively. The maximum ionisation density in these regions is known with fair accuracy. The particular layer which is effective in " reflecting " a given wave back to earth is determined by the wavelength used, time of day, season of year, period in sunspot cycle, latitude, etc. For the calculation of

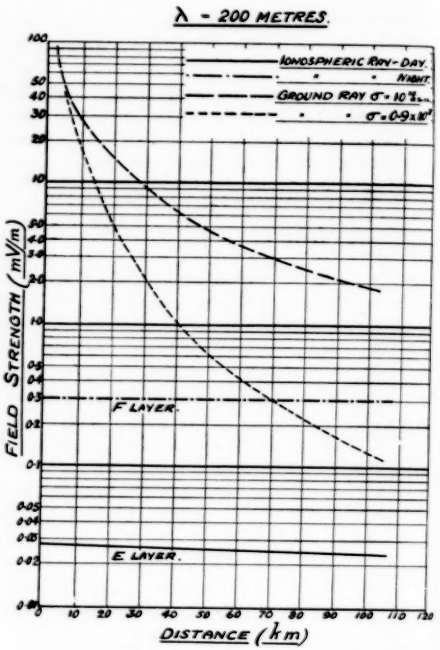

Fig. 4.

the total absorption, or " reflection coefficient " a knowledge of N and ν and other quantities such as the strength of the earth's magnetic field must be known throughout the layer or layers traversed by the wave.

Without entering into details, it may be said that our knowledge of the quantities required is too meagre for any attempt at calculating the reflection coefficient to be made successfully. Several workers have, by making certain plausible assumptions as to likely ionisation gradients and values for collisional frequency, attempted to solve special cases of the problem, particularly with a view to determining the likely variation of the reflection coefficient with wavelength, angle of incidence, etc. Such attempts have not yielded much success, the large variations with wavelength and angle of incidence forecast by theory not being

observed in practice. This has led Appleton and his co-workers to postulate another region of ionisation lower than any of the above-mentioned layers—a "D" region[4] which is largely responsible for absorption during the day and which, occurring in a region where ν is large but N not very large, is not effective in refracting the wave to any appreciable extent. The fact that regions of ionisation below the E layer do exist has recently been demonstrated directly as described in recent communications to "Nature."[5]

Enough has been said to show that it would be useless to attempt any theoretical computation of reflectional coefficients for the ionosphere, not only on account of the extreme complexity of the calculation but also, and to a greater extent, on account of the lack of sufficient data to perform the calculation.

5. Measurements of Reflection Coefficient at Ionosphere

A certain number of workers have, however, obtained experimental values for the reflection coefficient of the ionosphere for various wavelengths, and it is proposed to use such results as are obtainable and to extend their application in ways which may

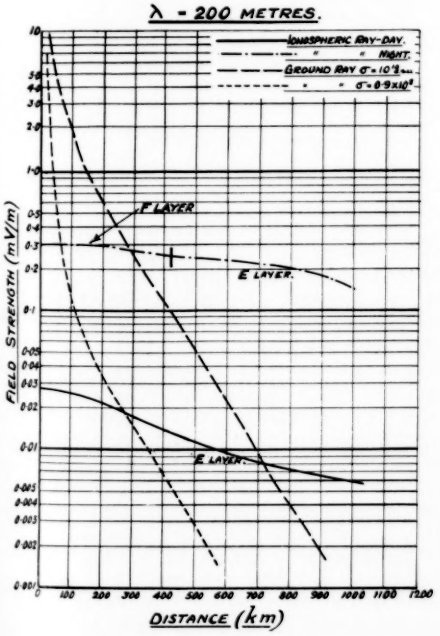

Fig. 5.

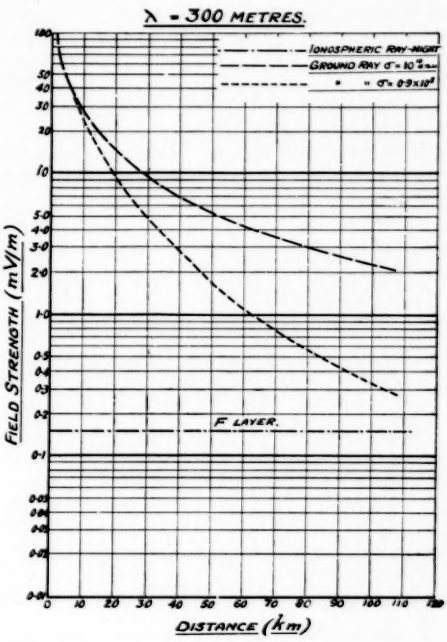

Fig. 6.

or may not be allowable, to calculate the intensity of the ionospheric ray for certain wavelengths.

In speaking of the "intensity of the ionospheric ray" it must be remembered that there are, in general, two rays, the ordinary and the extraordinary rays. If the wave incident on the ionosphere be plane polarised in the normal manner (vertically polarised), the ordinary and extraordinary rays both exist and are in general elliptically polarised having opposite senses of rotation. These rays will not, in general, arrive in phase because they are subject to different refraction effects. The mean intensity obtained when a number of waves arrive with random phase relationships is obtained by summing the energy (not the intensity) in the arriving waves. Thus if the two rays here dealt with have greatly different

intensities, as is usually the case, the mean intensity will not differ very much from that of the stronger of the two rays. Even when the two are of nearly equal intensity the error introduced by taking the mean intensity as equal to that of the stronger of the two cannot exceed about 40 per cent. This assumption has been made in what follows. Moreover, for very short ranges the angle between the direction of the ray and the direction of the earth's magnetic field is quite small, and in these circumstances the two rays will be approximately circularly polarised. The result is that over a long period of time the average intensity of the horizontally polarised component of electric force in the downcoming wave will be

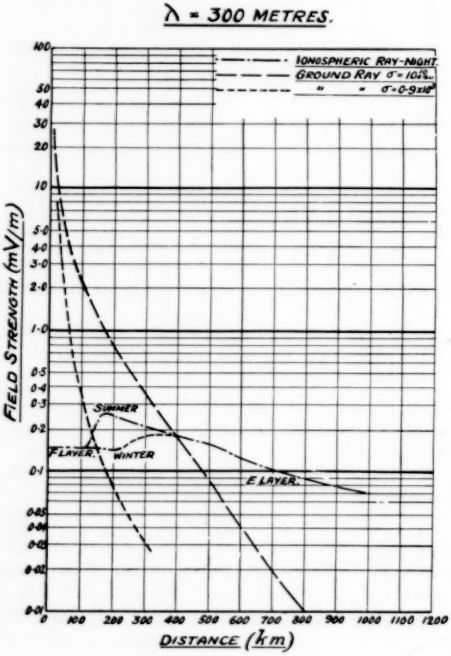

Fig 7.

about equal to the average intensity of the vertically polarised component.

Most measurements of reflection coefficient have been made at one angle of incidence only (viz., normal incidence). There is some evidence that it does not vary greatly with angle of incidence, and the assumption has been made that the reflection coefficient for any wavelength is a constant for all angles of incidence.

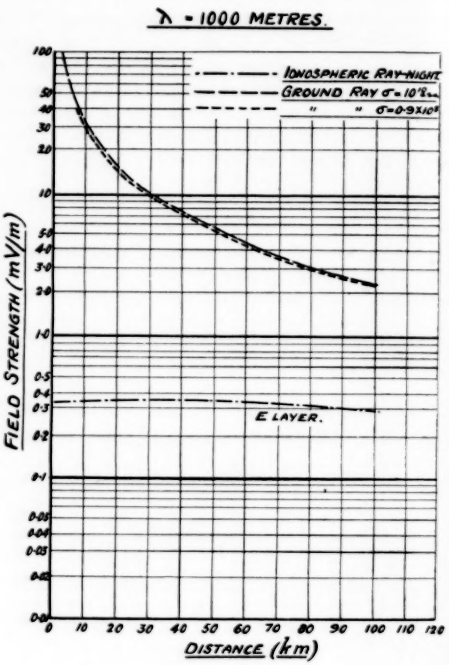

Fig. 8.

Another question which arises is that of multiply-reflected signals, i.e., signals which have been reflected more than once from the ionosphere. So far as these are concerned, we may take it that these are only of importance at distances greater than, say, 200 or 400 km. At ranges less than about 400 km., such signals have travelled considerably farther than a singly-reflected signal, and thus, even if perfect reflection occur at the ionosphere and the ground their effect on the resultant intensity is not great, particularly since they have random phase relationship with the singly-reflected signal.

At greater distances all waves, whether singly or multiply reflected, have approximately travelled the same distance, and at distances of 1,000 km. the effect of multiply reflected waves may become important. In

the following calculations, however, only one ray is assumed.

The question as to which layer, E or F, is effective in reflecting any particular wavelength back to earth has been decided by selecting mean values for the E and F critical frequencies for day and night periods in winter and summer from results obtained in the ionospheric research at Slough.

In selecting the best available values for reflection coefficients, the following publications have been consulted :—

Appleton and Ratcliffe, *Proc. Roy. Soc.*, vol. 128, p. 133.

Ratcliffe and Farmer, *Proc. Roy. Soc.*, vol. 151, p. 370.

D. F. Martyn, *Proc. Phys. Soc.*, vol. 47, p. 323.

F. W. G. White, *Proc. Phys. Soc.*, vol. 46, pp. 91 and 805.

The general conclusions arrived at after consultation of these papers are as follows :

Night conditions.

For wavelengths between 50 m. and 250 m. the reflection coefficient is approximately equal to 0.5, and for wavelengths between

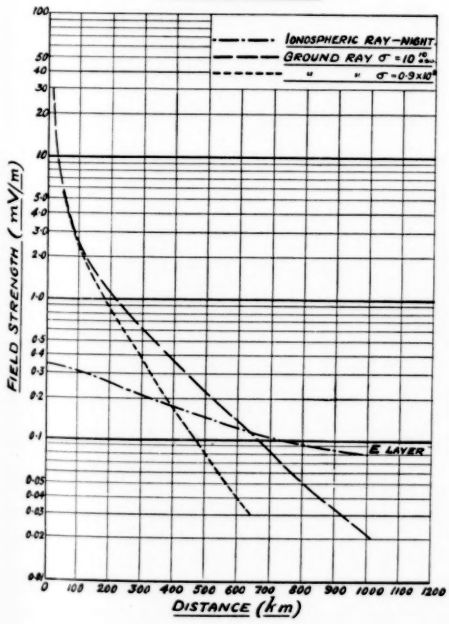

Fig. 9.

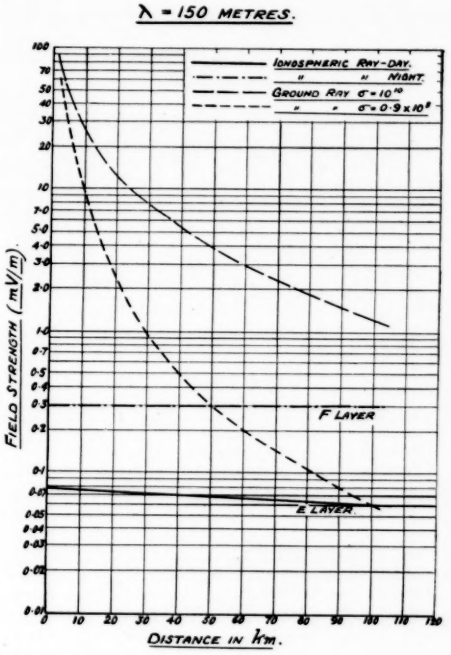

Fig. 10.

300 m. and 2000 m. reflection coefficient may be taken as 0.25.

Day conditions.

For wavelengths between 60 m. and 160 m. the reflection coefficient varies from 0.25 to 0.05. For wavelengths above 250 m. the reflection coefficient is less than 0.005 and thus the intensity of the reflected ray negligible over the range of the ground ray.

These results have been applied to the calculation of the intensity of the ionospheric ray on several wavelengths and for various ranges, and the results are given in graphical forms in Figs. 1 to 13. In the calculation the following assumptions have been made (in addition to any mentioned earlier in the paper).

The transmitter is an imaginary one having a vertical polar diagram which is a hemisphere i.e., radiating equally in all directions, the total power radiated being 1.5 kW.

The heights of the E and F regions have been taken as 110 km. and 250 km. respectively. The layer at which reflection is assumed to have taken place is noted against

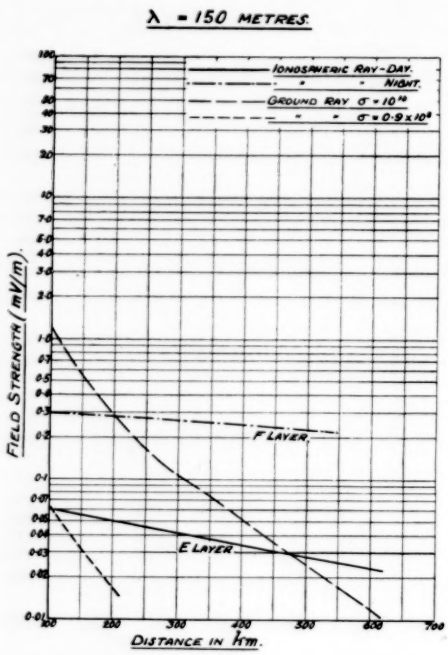

Fig. 11.

each curve. The curves are based on present conditions in the ionosphere.

6. Application of Results to Practical Cases

In practice most transmitters will radiate better horizontally than vertically. Let θ be the angle which any ray makes with the vertical through the transmitter (θ will also be the angle of incidence of the downcoming wave at the receiver). Suppose that the vertical polar diagram representing field intensity of the transmitter is given by $f(\theta)$, and suppose further that E_0 is the intensity of the downcoming ray, as given in attached curves, on a certain wavelength and at such a range that the angle of incidence with the vertical is θ, then the actual intensity E of the downcoming ray at this range and for this particular transmitter will be

$$E = E_0 f(\theta) \Big/ f\left(\frac{\pi}{2}\right),$$

it being assumed that the power radiated by the transmitter $f(\theta)$ has been adjusted so as to give the same intensity of ground wave as the fictitious transmitter used in deriving the attached curves.

For instance, with a simple vertical aerial of length small compared with the wavelength as transmitter, $f(\theta) = \sin\theta$ and thus

$$E = E_0 \sin\theta$$

The power radiated by such a transmitter will be 1 kw. to give the ground wave intensity shown.

The value of θ for any particular range can be obtained from a knowledge of the

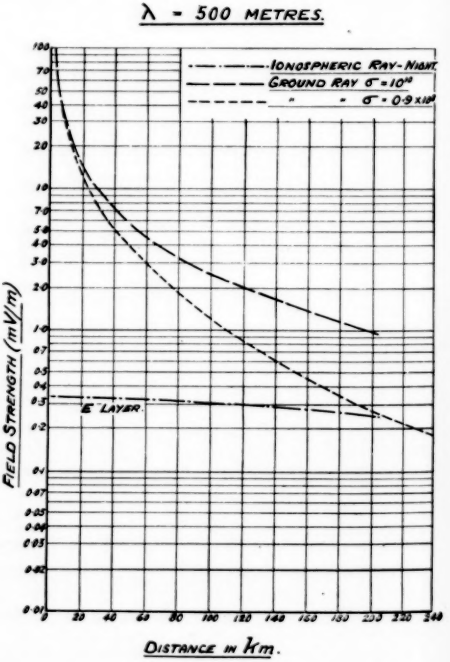

Fig. 12.

range and the height of the layer from which reflection is assumed to have taken place. A curve is given in Fig. 14 showing values of

θ for ranges up to 100 km. and reflection from either E or F regions.

It must also be noted that these curves

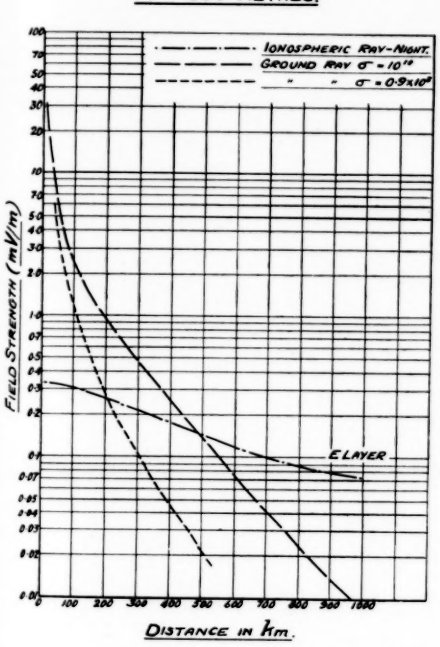

Fig. 13.

give simply the intensity of the electric vector (or of the magnetic vector in appropriate units) in the downcoming wave and take no account of reflection at the ground at the point of reception. It is assumed that, on the average, the electric vector is as often horizontal as vertical, and thus for the purpose of calculating the magnitude (but not phase) of the resultant magnetic and electric forces at the point of reflection, the downcoming wave may be treated as if it were circularly polarised having an electric vector given by the attached curves.

Thus, if we are concerned with the application of these results to loop direction-finders, we may proceed as follows.

Suppose a loop direction-finder to be under the combined action of a ground wave, whose magnetic vector has a value H_1 and a downcoming wave incident at an angle θ with the vertical, horizontally polarised (*i.e.*, with the magnetic vector in the vertical plane of propagation), the intensity of the magnetic vector being H, then the component of magnetic force at the ground in the plane of propagation is given by

$$a = (1 + \rho_h)\, H \cos\theta$$

where ρ_h is the reflection coefficient of the ground for horizontally polarised waves.

To a sufficient degree of approximation this may be written as

$$a = 2H \cos\theta$$

The maximum value of bearing error produced in the direction-finder will be ϵ where

$$\tan\epsilon = \frac{2H\cos\theta}{H_1}$$

$$\text{or } \tan\epsilon = \frac{2E\cos\theta}{E_1}$$

where E and E_1 are the magnitudes of the

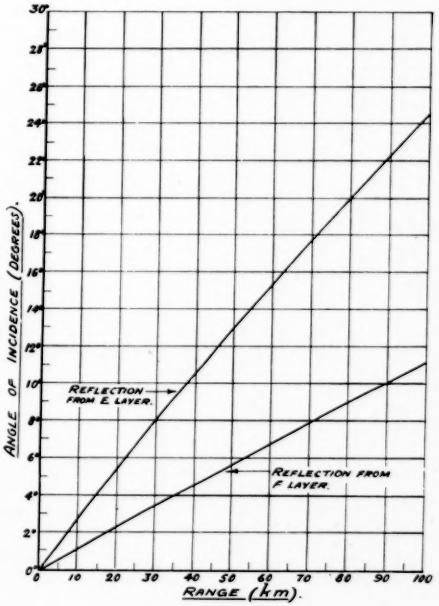

Fig. 14.—*Angle of incidence for reflecting from E and F layers for various ranges.*

electric vectors in the downcoming and ground rays respectively.

E is related to E_0 the value of the electric vector of the downcoming wave given in the attached curves by the relation

$$E = E_0 f(\theta) \Big/ f\left(\frac{\pi}{2}\right)$$

where $f(\theta)$ is the function representing the vertical polar diagram of the transmitting aerial.

Thus for a transmitter having a short vertical aerial

$$E = E_0 \sin \theta$$

and $$\tan \epsilon = \frac{2E_0 \sin \theta \cos \theta}{E_1} = \frac{E_0 \sin 2\theta}{E_1}$$

Thus if a polarisation error of 1° is permissible then $\frac{E_0 \sin 2\theta}{E_1}$ must be $\leqslant 0.0174$ where E_0, E_1 are read directly from the curves given.

It may be added that for ranges up to 100 km. and for reflection from F layer, $\cos \theta$ may be taken as unity with an error of less than 2 per cent., and for reflection from E layer the same holds true for ranges up to 50 km. Thus within these ranges $\sin 2\theta$ may be written as $2 \sin \theta$.

Let us take as an example the case of a wavelength of 1,000 metres. Reflection (at night) is from the E layer.

Range	E_1	E_0	$E_0 \times 2 \sin \theta$	$\frac{E_0 \times 2 \sin \theta}{E_1}$	Max. Error in Bearing
km.	mV/m.	mV/m.	mV/m.		Degrees.
20	15	0.35	0.063	0.0042	0.25
30	10	0.35	0.092	0.0092	0.53
40	7.5	0.35	0.123	0.0164	0.93
50	6.0	0.35	0.152	0.0252	1.43

Thus (approximately) for ranges beyond 40 km. we may expect a (variable) polarisation error of more than 1° max.

To apply the results to other forms of direction-finder we must calculate the resultant components of electric force at the point considered, which are effective in producing bearing errors. For instance, with Adcock direction-finders the component of force giving rise to error is the resultant component of electric force perpendicular to the plane of propagation. To calculate this, ρ_h may no longer be taken as unity but must be given a more correct value.

Summary and Conclusions

The paper is chiefly concerned with an attempt to calculate the relative intensities of the ground ray and the ionospheric ray in order to estimate the effective ranges within which closed loop direction-finding apparatus may be used with freedom from polarisation errors.

The estimated value of the ionospheric ray must be accepted with some caution, in view of the scanty data available for its computation and the assumptions which have had to be made. The possible working ranges of loop direction-finders, which may be derived from the results given here, are probably under-estimated rather than over-estimated, and the uncertainty in the precise range may be of the order of a factor of 2.

Subject to these restrictions, the information in this paper will provide some guide as to the possible working range of loop direction-finders or other direction-finders whose behaviour when under the influence of a wave of variable polarisation is known.

Acknowledgments

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Time Sweep of a Cathode-Ray Oscillograph*

Calibration Using a Valve Time-base

By F. C. Williams, M.Sc., D.Phil., and J. P. Wolfenden, B.Sc.

IN making quantitative measurements on cathode-ray oscillograms obtained with the aid of a valve time-base, considerable errors may arise if the time-base is not calibrated, for unless it is perfectly linear over the whole of its sweep, a given distance does not represent the same angle at different positions along the X axis. The accurate determination of angles by direct measurement is then impossible and some form of time calibration is necessary. When photographic records are taken a similar inaccuracy may be introduced by screen curvature. Further, when voltages of irregular waveform are recorded it is often necessary to obtain an accurate zero line. Such a line can be

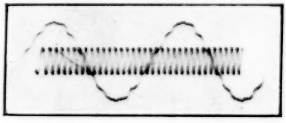

Fig. 1.

drawn on the recorded oscillogram if the time base has been calibrated, for the mean ordinate measured from any arbitrary line parallel to the X axis can be determined.

The apparatus to be described is designed to work from the A.C. power supply and has been of great assistance in the measurement of phase angles between voltage and current waves, ignition angles and phase overlap in grid-controlled mercury arc rectifiers and in the examination of irregular wave forms.

In order to explain various features of the apparatus it is necessary to mention several experimental models which were tested before the final apparatus was evolved.

If the output from an ordinary valve oscillator is applied to the Y plates of an oscillograph the distances between successive peaks represent equal time intervals. Moreover, if the frequency of the oscillator is high relative to that of the wave to be examined,

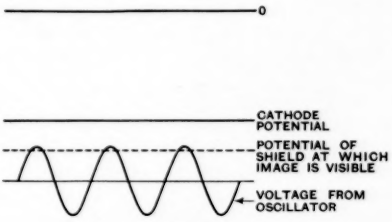

Fig. 2.

these distances become small and accurate calibration is possible. The obvious disadvantage of this method lies in the superposition of a complete calibrating oscillation, on the wave studied, with the result that the wave is either obscured or restricted to a portion of the screen only. An example of such calibration is shown in Fig. 1.

This disadvantage can be overcome by transferring the oscillator output from the Y plates to the shield or modulator electrode of the oscillograph. Suitable adjustment of the steady bias voltage applied to the shield then results in the time sweep being broken into a dotted line, the distances between the dots representing equal time

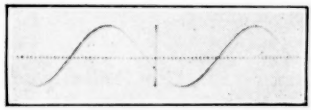

Fig. 3.

intervals. The mechanism by which this result is obtained is sufficiently explained by Fig. 2, which shows the variation of shield voltage with time.

It is understood, of course, that the time-

* MS. accepted by the Editor, November, 1936.

base remains connected to the X plates and that its controls must not be adjusted between the recording of test wave and calibration. The resulting calibration is illustrated in Fig. 3. The dots can be replaced by short and almost vertical straight lines, as shown in Fig. 4, by feeding a portion of the oscillator output to the Y plates and causing this voltage to lag 90° behind the voltage applied to the screen. However, the results obtained by this arrangement, a diagram of which is shown in Fig. 5, did not justify the necessary additional apparatus.

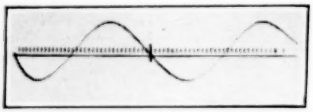

Fig. 4.

The subsequent quantitative examination of the recorded oscillogram is greatly facilitated by the provision of a convenient number of calibration marks per cycle of the wave examined, but even if the frequency of the oscillator were adjusted to give this result, any slight variation of oscillator frequency would cause the dots to move across the screen. To overcome this difficulty a fixed frequency oscillator has been designed for use in measurements at power frequencies which is driven from the power supply and whose frequency is controlled by the supply frequency. It is designed

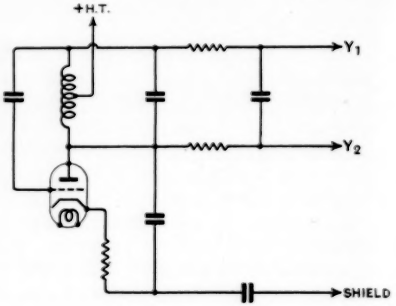

Fig. 5.

to operate at 1,800 c/s. since this not only yields a convenient number of dots per cycle of the 50-cycle supply but is also readily controlled therefrom.

The general principle of operation involves the use of two oscillators, the first being driven by a harmonic of the supply voltage and the second by a harmonic of the first oscillator. The circuit used is shown in Fig. 6.

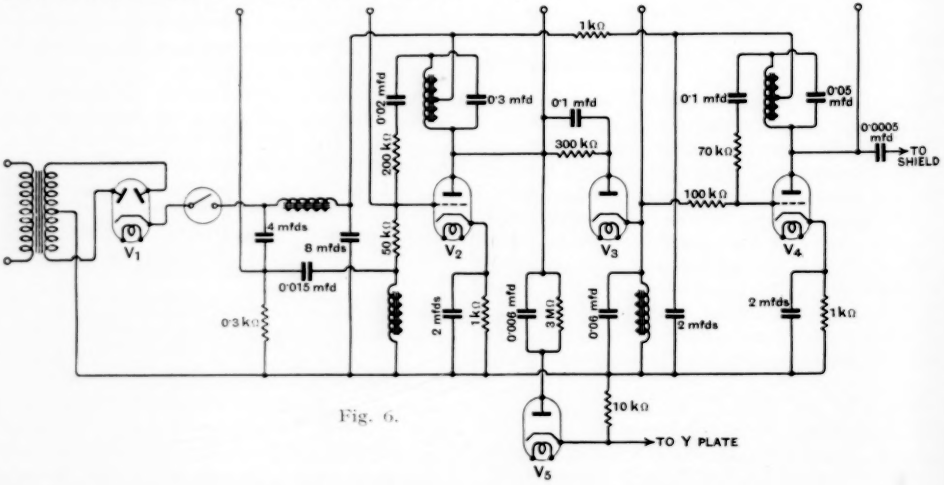

Fig. 6.

The first stage is essentially a simple full-wave rectifier except that a 300-ohm resistance is included in series with the first smoothing condenser. A series resonant

circuit selects the third harmonic of the much distorted 100-cycle wave which appears across this resistance and supplies it to the first oscillator. This oscillator is arranged to yield a weak oscillation at a frequency of 300 c/s, and is held at that frequency by the selected harmonic.

The second oscillator is adjusted to a frequency of 1,800 c/s and is similarly locked to the sixth harmonic of the first oscillator by means of a distorting diode rectifier and resonant circuit.

The output of the second oscillator is fed to the shield of the cathode-ray tube through a high voltage condenser which must be capable of withstanding the maximum anode voltage applied to the oscillograph tube.

In order to permit easy counting of the dots it is convenient to displace every sixth dot by applying a suitably distorted voltage at a frequency of 300 c/s to the Y plates.

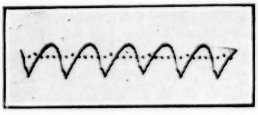

Fig. 7.

This displacing voltage is provided by the diode V_5 (*see* Fig. 6). The distance between displaced dots then represent an angle of 60° reckoned relative to the wave examined, horizontal distances between adjacent dots represent 10°.

Fig. 7 is an oscillogram showing the resulting calibration applied to the measurement of phase overlap in a mercury arc rectifier.

In constructing the apparatus it was found convenient to provide the inductances with adjustable iron cores which were clamped in position after the circuits had been tuned. Rapid readjustment of frequency in the event of changes in the power supply was facilitated by the provision of five plug connections, on an external terminal board, connected to the points shown in Fig. 6. The oscillograph is used to indicate correct adjustment by synchronising the time-base with the power supply and connecting the Y plates to the circuit concerned.

The apparatus described was specially designed for supply frequency measurements but the principle might well be applied to measurements at other frequencies. In such cases the first oscillator would be synchronised from the source supplying the test voltage.

Acknowledgment

The apparatus was designed in the Electro-Technical laboratories of Manchester University and the authors are indebted to Professor Beattie for the facilities placed at their disposal.

Correspondence

Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain

The Three Halves Power Law of the Diode

To the Editor, The Wireless Engineer.

SIR,—Mr. E. B. Moullin's letter on the above subject in your April issue was of great interest to me as, some time ago, in attempting to obtain a simple physical argument to derive this relation, I developed an elementary non-mathematical treatment which, although not rigorous, I have found helpful to beginners.

Consider an ideal parallel plane diode in which unlimited emission and zero initial velocities are assumed. The application of a positive potential to the anode will cause a current to flow and a space charge to be produced. The agent producing the flow of electrons is the electric intensity at the cathode surface and as the accelerating field at the cathode is obviously diminished by the presence of space charge the equilibrium condition will be reached when the field at the cathode surface just vanishes. In this condition the total space charge must be just equal and opposite to the total charge on the anode surface. Therefore the total space charge will be proportional to the electric intensity or potential gradient at the anode surface. Similarly, the total space charge lying between any equipotential surface in the inter-electrode space and the cathode will be proportional to the potential gradient at the surface considered.

The accelerated electrons, when crossing any plane equipotential section of potential V will have a velocity proportional to $\sqrt{V}$ and further, the current, which must be the same at all sections, will be proportional to the product of the space charge density and the electron velocity at the section considered.

The curve of potential against distance, x, between cathode and anode must be tangential to the x axis at the cathode and must pass through the point $x = d$, $V = V_a$, where d is the inter-electrode spacing and V_a the anode potential.

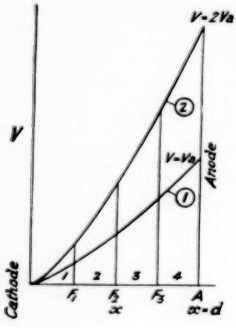

Fig. 1.

Assume some plausible distribution such as curve 1, Fig. 1. Suppose that the anode potential is now increased to $2V_a$. The new curve must again be tangential at the origin and must now pass through the point $x = d$. $V = 2V_a$. The simplest reasonable assumption is that the new curve is formed from curve 1 by doubling all its ordinates. Let this be assumed. The gradient of curve 2 for any given value of x is then twice that of curve 1. Thus the electric intensity is doubled at every point.

Let the inter-electrode space be divided by a number of parallel plane sections into "slabs," e.g. 4, the position of the interfaces being shown as F_1, F_2, etc. in Fig. 1. The total space charge lying between section F_2 and the cathode must be twice as great for curve 2 as for curve 1 and similarly for any other section, e.g. the adjacent one F_3.

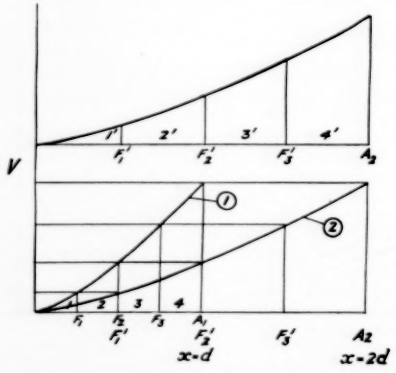

Fig. 2.

Therefore the total space charge in slab 3 is twice as great for $V = 2V_a$ as for $V = V_a$. Doubling the anode voltage thus doubles the space charge density at every point. At the anode surface the space charge density has been doubled and the electron velocity will have increased $\sqrt{2}$ times. The anode current is therefore increased in the ratio of 1 to $2 \times \sqrt{2} = 2^{\frac{3}{2}}$, or in general, anode current, $I_a \propto V_a^{\frac{3}{2}}$.

Now consider, in a similar way the effect of altering the electrode spacing. Let it be assumed, as indicated in Fig. 2 that the effect of doubling the electrode spacing is to double the abscissae of curve 1. The gradient of curve 2, Fig. 2, for any particular value of V will then be half that of curve 1. Thus the total space charge lying between section F_2' and the cathode (Curve 2) will be half the value of space charge lying between section F_2 and the cathode (curve 1), and similarly for sections F_3' and F_3. Therefore the total space charge between sections F_2' and F_3' is half that between sections F_2 and F_3. But the volume of slab 3′ is twice that of slab 3 therefore the space charge density is everywhere reduced to $\frac{1}{2} \times \frac{1}{2} = \frac{1}{2^2}$ of its previous value. At the anode surface the electron velocity is unchanged but the space charge density is reduced to $\frac{1}{4}$, so that the anode current is reduced in the same ratio. Thus, for V_a constant $I_a \propto \frac{1}{d^2}$, and in general $I_a \propto \frac{V_a^{\frac{3}{2}}}{d^2}$.

The argument is not, of course, in any sense rigorous but serves to illustrate very simply the physical processes involved.

The University, Birmingham. JAMES GREIG.

Frequency Changers

To the Editor, The Wireless Engineer.

SIR,—It may be of interest to mention that since the article in the April issue of *The Wireless Engineer* on Octode Frequency Changers was written by Dr. Strutt a triode-hexode has been developed in the Mullard Laboratories which avoids most of the effects mentioned by him.

The oscillator slope of this new triode-hexode is rather high, being of the order of 6 mA per volt at the starting point of oscillation. Oscillator circuits may, therefore, be loosely coupled to the valve which practically eliminates frequency drift.

The Mullard Wireless Service Co., Ltd.
London, W.1. T. E. GOLDUP.
(Head of Technical Service Dept.)

Television Exhibition

A TELEVISION Exhibition at the Science Museum, South Kensington, to which admission will be free, will be opened to the public on Friday, June 11th, and is expected to last for three months. Each weekday it will be open at 10 a.m. and close at 6 p.m. on Mondays, Tuesdays and Wednesdays, and two hours later on Thursdays, Fridays and Saturdays. It will not open until 2.30 p.m. on Sundays and close at 6 o'clock.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

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PROPAGATION OF WAVES

2050. PHASE-VELOCITY OF ELECTROMAGNETIC WAVES ALONG THE GROUND.—W. Ross & E. C. Slow. (*Nature*, 17th April 1937, Vol. 139, p. 671.)

The writers have measured the phase velocity of radio waves of frequency 2.5–15 Mc/s by a cathode-ray-oscillograph determination of the phase difference between two vertical aerials at a known distance apart in the direction of propagation of the waves. The measured values lie very close to the value 3×10^{10} cm/sec; "there is no indication of a marked change in velocity with frequency" so that the group velocity will differ only slightly from the velocity of light. "These results are not in agreement with those of Colwell, Hall, & Hill" (438 of February) whose measurements however refer to "a pulse which has travelled some kilometres and may not have remained quite close to the ground all the way."

2051. THE INFLUENCE OF THE WATER CONTENT ON THE RESISTANCE OF GEOLOGICAL CONDUCTORS.—V. Fritsch. (*E.T.Z.*, 25th March 1937, Vol. 58, No. 12, pp. 319–320.)

"The resistance of the solid component is, with a few exceptions, so high that the currents flowing therein may be neglected. The effective resistance depends almost exclusively on the liquid component. The relation between resistance and water content is complicated, and dependent on many subsidiary conditions. Badly conducting kinds of rock, which electrically differ very little from their surrounding medium, can sometimes be detected electrically by the solutions to which they give rise" [in wet weather the water which penetrates into them forms solutions whose nature and degree of saturation depends on hydrological and mineral-chemical factors].

2052. RADIO EXPERIMENTS IN SUMMER, 1936, ON THE DANUBE BETWEEN PASSAU AND RUSSE.—V. Fritsch. (*Hochf:tech. u. Elek:akus.*, March 1937, Vol. 49, No. 3, pp. 94–98.)

For previous work *see* 2522 of 1936 and back references. Here, the deformation produced by rivers and hills in the propagation of waves from an emitter is first discussed (§ I; Figs. 1–2e). Experiments on the upper Danube on a wavelength of 10 m are described in § II; the polar diagram of an emitter in a bend of the river was determined (Figs. 4, 5 with vertical and horizontal dipole respectively). Reception in a narrow valley was also tested (Fig. 6). Reception of the broadcasting station at Linz (frequency 886 kc/s) was measured (Fig. 7). Similar reception experiments were made on the lower Danube (§ III; Figs. 8, 9). The general conclusions reached were that (1) subterranean water-courses have a considerable effect on the polar diagram; (2) communication is possible on the 10 m-band even in narrow winding valleys; (3) cataracts have a marked absorption effect which may be due in this case to mineral deposits in the surrounding hills; (4) in the cataracts, no emitter could be heard satisfactorily in the day-time; useful communication along such stretches of the river is confined to the night-time.

2053. THE MOTION OF ELECTRONS IN A GAS IN THE PRESENCE OF VARIABLE ELECTRIC FIELDS AND A CONSTANT MAGNETIC FIELD.—V. A. Bailey. (*Phil. Mag.*, April 1937, Series 7, Vol. 23, Supp. No. 156, pp. 774–791.)

This general theory starts by considering the mean work done on an electron per collision and proving the theorem that "the total average energetic effect of the forces of different frequencies is equal to the sum of the separate average effects." The determination of the collision frequency by approximate and graphical methods is discussed; the theory is illustrated by "the study of the effects caused by a sinoidal electric field," and by "an electric field having two undamped components of different frequencies, which are parallel to each other and perpendicular to the magnetic field." The possible existence of hitherto unrecognised phenomena in the interaction of radio waves is pointed out; "two waves whose fre-

quencies differ only by an audible frequency may cause variations in the collision frequency of an audible kind, and so may produce an audible background in the reception of a third wave whose frequency differs considerably from the frequencies of the other two . . . a kind of resonance may occur in the well-known radio-interaction of two waves when the frequency of one of them passes through the value of the local gyro-frequency" (*see* also 840 of March).

2054. RESONANCE DISPERSION IN IONISED GASES [and Wave Propagation in the Ionosphere: Experimental Investigation].—W. Sigrist. (*Helvet. Phys. Acta*, Fasc. 2, Vol. 10, 1937, pp. 73–106: in German.)

For previous work *see* 3315 of 1935. From the author's summary:—" The resonance dispersion of ionised gases observed by various authors [*e.g.* Gutton] is a true electron resonance. My researches on the amplitude-dependence of the resonance-ion density show definitely that the quasi-elastic binding of the electrons is a macro-binding in the sense of Langmuir's picture of plasma oscillations. The phenomena can be explained only by the inhomogeneous distribution of the ionic density along the electric-field vector. On this assumption a complete interpretation of the phenomena of resonance dispersion is possible."

The writer points out that various workers have tried to use the phenomena of plasma resonance for the explanation of certain results in the propagation of electromagnetic waves in the ionosphere. " But plasma resonance is a very definite inhomogeneity effect, in which the inhomogeneity must occur in the direction of the electric field and . . . must extend over regions whose dimensions do not exceed the length of a wave. It is very difficult, if not impossible, to assume a corresponding structure for the ionosphere . . . Resonance dispersion in an ionic plasma is seen to be a definite 'container effect' arising from the decrease of ionic density at the confines of spatially limited gas discharges. It is thus particularly important in the phenomena of discharges in apparatus such as rare-gas and metal-vapour rectifiers, metal-vapour lamps, etc., but not in the very extensive ionosphere."

2055. DIELECTRIC CONSTANT OF AN ELECTRONIC ATMOSPHERE FOR ULTRA-SHORT WAVES.—A. Imam & S. R. Khastgir. (*Indian Journ. of Phys.*, Feb. 1937, Vol. 11, Part 1, pp. 37–48.)

" Measurements of the dielectric constant of an electronic medium between the plate and the filament of a dull-emitting screen-grid valve (and also of a triode) have been made for different thermionic currents and for a certain range of ultra-short wavelengths [4–5.1 m]. The dielectric constant has been found first to decrease and then to increase with the increasing values of the thermionic current. This variation has been explained in view of certain characteristic features associated with the thermionic valves" [effect of time of stay of electrons in the inter-electrode space: effect of non-uniform distribution].

" The dielectric constant has been found to decrease with the wavelength for the shorter wavelengths. This variation is not in perfect agreement with the Eccles-Larmor formula. Beyond a certain wavelength the dielectric constant increases again with the wavelength. The unmistakable turning point in the dielectric-constant/wavelength curve suggests some kind of resonance effect."

2056. PROPERTIES OF THE 10 M WAVE IN OVERSEAS TRAFFIC [Short Description of Conditions in 1935/36].—E. Fendler. (*Hochf: tech. u. Elek:akus.*, Feb. 1937, Vol. 49, No. 2, pp. 56–57.)

2057. RECEPTION ON 28 Mc/s [Distances 50–500 Miles: Regular Reception of Type unlike the High-Angle Refraction Type met with in Summer].—D. W. Heightman. (*Wireless World*, 2nd April 1937, Vol. 40, pp. 338–339).

2058. MICRO-WAVES: PART V—PROPAGATION.—Carrara. (*Alta Frequenza*, March/April 1937, Vol. 6, No. 3/4, pp. 209–214 and 245–246.) Conclusion of the series referred to in 1736 of May.

2059. OBSERVATIONS OF THE DELLINGER EFFECT ON 6TH NOV. 1936 [at Pieskow, Beelitz, and elsewhere].—H. A. G. Hess. (*Funktech. Monatshefte*, March 1937, No. 3, pp. 74–76.)

Author's summary:—" The Dellinger effect has its origin in an influence, proceeding from the sun, on the ionisation of the Kennelly-Heaviside layer. The eruption centres of hydrogen flocculi are the cause, either by radiation or by electron emission. These eruptions have a short duration; the layer receives from them an extremely high increase of ionisation in a very short time, whereby the day waves used in transoceanic services suffer a weakening in reflection or an absorption, as a result of too steep ionisation gradients, until the charges have been dissipated and equilibrium is restored. Ultra-short waves around 8 m are not affected in their propagation by the Dellinger phenomenon, since in any case a high degree of ionisation is necessary for their reflection. It may therefore be expected that in certain conditions a transoceanic propagation of waves around 5 m would be possible during a Dellinger disturbance [thus the writer learns that in the afternoons of 5th & 6th Nov. the 6.9 m sound transmission from the Alexandra Palace, and probably also the 7.1 m signals from Witzleben, were received in Johannesburg].

" Further, the action of the Dellinger effect seems to increase proportionately with the angle of incidence of the sun's rays on the great circle joining the transmitter and receiver, and with the length of path illuminated by the sun. On the other hand the action is inversely proportional to the radiated frequency. Thus frequencies around 30 Mc/s are less affected than those around 20 Mc/s, while at 40 Mc/s no disturbance can be found."

2060. EFFECT OF THUNDERSTORMS AND MAGNETIC STORMS ON THE IONISATION OF THE KENNELLY-HEAVISIDE LAYER.—Bhar & Syam. (*See* 2077.)

2061. HEIGHTS OF REFLECTION OF RADIO WAVES IN THE IONOSPHERE.—F. H. Murray & J. B. Hoag. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, pp. 333–341.) The full paper, an abstract of which was referred to in 1274 of April. The theoretical method used to calculate geometrical heights of reflection from observed virtual heights is given here.

2062. THE PHYSICS OF THE IONOSPHERE [Survey with over 300 Literature References].—H. R. Mimno. (*Reviews of Mod. Physics*, Jan. 1937, Vol. 9, No. 1, pp. 1–43.)

Including sections on the nature of the accelerating field, Gutton's "quasi-resonance" (and Appleton's refutation), analysis of magneto-ionic double refraction, collisional friction, "fine structure," tidal effects, local ionospheric clouds, interaction, etc. In connection with interaction the writer mentions the "inertia" results of Ferrier & Donder (1930 Abstracts, p. 449) in optical telephony, when they found that an absorber placed near the transmitter, where the rays were concentrated, had a different effect from that produced by the same absorber placed in the weaker radiation field near the receiver.

2063. THE "ONGAR" PULSE CIRCUIT [giving 0.0001 Sec. Pulses: originally used to Key the 40 kW Ongar Transmitter].—G. Millington. (*Marconi Review*, Nov./Dec. 1936, No. 63, pp. 1–6.)

2064. RECORDED OBSERVATIONS OF THE FADING OF TWO STATIONS [One 850 km away, the Other 220 km: Completely Different Behaviour under Otherwise Similar Conditions].—R. Theile. (*Funktech. Monatshefte*, March 1937, No. 3, pp. 83–85.)

2065. A D.C. AMPLIFIER FOR LOGARITHMIC RECORDING [for Broadcast Field Intensity Measurement and Other Purposes: 5 mA Output across Load up to 5000 Ohms for 3 Volt Input (less than 10 μA)].—J. P. Taylor. (*Electronics*, March 1937, Vol. 10, No. 3, pp. 24–27 and 35.)

2066. THEORETICAL CALCULATION OF THE DISTRIBUTION OF THE OZONE FORMED BY PHOTO-CHEMICAL ACTION IN THE ATMOSPHERE.—Wulf & Deming. (*Journ. de Phys. et le Radium*, Jan. 1937, Vol. 8, No. 1, pp. 170–171S.)

2067. ABSORPTION OF OXYGEN AT THE LIMIT OF THE SOLAR SPECTRUM [Experimental Study: Contribution of Oxygen to Absorption of Ultra-Violet Solar Radiation is practically Zero].—L. Herman. (*Comptes Rendus*, 31st March 1937, Vol. 204, No. 13, pp. 1035–1037.)

2068. ON THE PRODUCTION OF AURORAL AND NIGHT-SKY LIGHT [Night-Sky Lines and Bands produced by means of the Dissociative Energy of Oxygen: Important Rôle of Metastable Nitrogen: Excitation of Auroral Spectrum by Impact of External Particles on Nitrogen Molecules].—S. Chapman. (*Phil. Mag.*, April 1937, Series 7, Vol. 23, Supp. No. 156, pp. 657–665.)

2069. ELECTRONIC ORIGIN OF THE NITROGEN BANDS IN THE SPECTRUM OF THE AURORA BOREALIS. DETERMINATION OF ENERGY OF EXCITING ELECTRONS.—R. Bernard. (*Comptes Rendus*, 22nd March 1937, Vol. 204, No. 12, pp. 993–995.) For previous work *see* 1681 of May.

2070. ON CHEMICAL REACTION IN THE ELECTRIC DISCHARGE: II—THE SYNTHESIS OF NITRIC OXIDE [as Product of Glow Discharge in Nitrogen/Oxygen Mixtures: Reaction may proceed *via* Metastable Oxygen Molecule: Ion Clusters need not be introduced for Interpretation of Such Electrical Reactions].—E. J. B. Willey. (*Proc. Roy. Soc.*, Series A, 15th March 1937, Vol. 159, No. 897, pp. 247–262.)

2071. AN ATTEMPT TO DETECT THE PRESENCE OF METASTABLE ATOMS IN ACTIVE NITROGEN BY LIGHT ABSORPTION [Negative Results].—Herbert, Herzberg, & Mills. (*Canadian Journ. of Res.*, March 1937, Vol. 15, No. 3, Sec. A, pp. 35–38.)

2072. ALTITUDES AND SPECTRA OF RED AND SUNLIT AURORAS [Data of Recent Norwegian Observations].—C. Störmer. (*Nature*, 3rd April 1937, Vol. 139, p. 584.)

2073. OBSERVATIONS OF THE AURORA AND THE ZODIACAL LIGHT [since 1931].—(*Nature*, 10th April 1937, Vol. 139, p. 642: note on Memoir 32, Part 3, issued by British Astronomical Association.)

2074. THE SOLAR AND MAGNETIC CONDITIONS ASSOCIATED WITH RECENT AURORAS.—J. P. Rowland. (*Nature*, 17th April 1937, Vol. 139, pp. 680–681.)

2075. TERRESTRIAL MAGNETIC VARIATIONS AND AURORAE [Summary and Comparison of Theories].—E. O. Hulburt. (*Reviews of Mod. Physics*, Jan. 1937, Vol. 9, No. 1, pp. 44–68.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2076. ON THE ORIGIN OF INTERSTELLAR RADIO DISTURBANCES [Black-Body Radiation fails by Factor of 10^4 to explain Observations].—F. L. Whipple & J. L. Greenstein: Jansky. (*Proc. Nat. Acad. Sci.*, March 1937, Vol. 23, No. 3, pp. 177–181.) It is therefore "particularly necessary to investigate more thoroughly the actual dependence of the received intensity on wavelength, a problem which is now being attacked by one of the authors."

2077. EFFECT OF THUNDERSTORMS AND MAGNETIC STORMS ON THE IONISATION OF THE KENNELLY-HEAVISIDE LAYER.—J. N. Bhar & P. Syam. (*Phil. Mag.*, April 1937, Series 7, Vol. 23, No. 155, pp. 513–528.)

Theoretical considerations lead the writers to search for a "correlation between thunderstorm activity and abnormal increases of ionisation by taking into account thunderstorms . . . within a radius of 200 km round Calcutta." E-region

ionisation was observed and abnormal ionisations classified and compared with data of thunderstorms and magnetic storms. It is concluded that there is "a marked association between the occurrence of a thunderstorm and an abnormal increase in E-region ionisation; the association, if any, between magnetic disturbance and abnormal ionisation of the E region is not very marked; there is no association between magnetic disturbances and thunderstorms."

2078. At What Point does a Lightning Stroke "make for" Its Striking Place?—B. Walter. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 18, 1937, pp. 105–109.)

Every photograph known to the writer of lightning striking a high tower shows a distinct "kink" in the course of the flash at quite a small distance from the striking place: it is thought that only at this point does the lightning "become aware of" the tower. This confirms the belief that the radius of protection of a high tower provided with a lightning conductor is only slightly greater than the height of the tower above its surroundings

2079. Lightning Reference Book to be Issued Soon [Notice of AIEE Publication].—(*Elec. Engineering*, April 1937, Vol. 56, No. 4, p. 488.)

2080. The Effect of Air Velocity on the Spark between Point-Plate and Two-Point Electrode Systems in Atmospheric Air [Little Effect on Spark-Over Potential of Point-Plate System].—Wheatcroft, Smith, & Hoyle. (*Phil. Mag.*, April 1937, Vol. 23, Supp. No. 156, pp. 718–726.)

2081. Discussion on "A Disturbance Duration Recorder."—Frier. (*Elec. Engineering*, March 1937, Vol. 56, No. 3, pp. 367–368.)

2082. Radio-Transmitted Coincidence-Counter Measurements of Cosmic-Ray Intensities in the Stratosphere [Coincidence transmitted as Pulse of H. F. Waves].—T. H. Johnson. (*Journ. Franklin Inst.*, March 1937, Vol. 223, No. 3, pp. 339–354.)

2083. Variations of the Electrical Conductivity of the Air as a Function of Barometric Depression, in the Pneumatic Chamber [Increase of Conductivity with Decreasing Pressure is probably due largely to Increased Mobility of Ions].—J. Cluzet & P. Ponthus. (*Comptes Rendus*, 22nd March 1937, Vol. 204, No. 12, pp. 995–997.)

PROPERTIES OF CIRCUITS

2084. A Method of Investigating the Transient Characteristics of Electrical Circuits [Development of Infinite Integral Theorem to a Form suitable for Graphical Calculation: Use of Cathode-Ray Oscillograph], *also* Note on the Analysis of Transients, *and* A Form of the Infinite Integral Theorem Valid for Circuits which pass a Steady Current.—R. N. Morse: W. G. Baker: W. G. Gordon. (*Journ. I.E.E. Australia*, Feb. 1937, Vol. 9, No. 2, pp. 77–82: 82: 82–83.)

"Various qualitative applications suggest themselves, such as for the design of tone-compensated receivers and more particularly television amplifiers. The transient response of filter circuits and telephone lines, and distortion in amplifiers, can also be conveniently examined."

2085. The Symmetry Conditions in Coupled Filters.—H. Baumgartner. (*Hochf:tech. u. Elek:akus.*, Feb. 1937, Vol. 49, No. 2, pp. 65–67.)

Remark on a paper by Troeltsch & Steinmetz (3357 of 1936). The writer finds that "the symmetry conditions there given for phase-pure coupled circuits do not correctly reproduce the actual conditions, as they do not consider the detuning effect of the coupling member." The theory of the coupled filter (Fig. 1), the capacitatively- and inductively-coupled band-filters (Figs. 2, 3), a coupling member involving loss, and band-filters of variable pass width is discussed. It is found that the detuning effect can be compensated by proper tuning of the coupled circuits and symmetry attained; formulae are given for the cases mentioned.

2086. The Effect of Various Types of Adjustment on the Asymmetry of Broadcast Band Filters.—E. Alsleben. (*Hochf:tech. u. Elek:akus.*, March 1937, Vol. 49, No. 3, pp. 98–100.)

The writer refers to work by Feldtkeller & Tamm (2992 of 1936) in which asymmetry in a band filter with the equivalent circuit of Fig. 1 of the present paper is discussed. He shows by calculation that if the equivalent circuit contains coupling by a mutual inductance (Fig. 2), the adjustments in the work referred to cannot be carried out. The adjustment can only be done by the circuits shown in Fig. 3, in which case the asymmetry resulting from different capacities with different time constants is shown not to occur; the asymmetry "can be avoided if, for adjusting on one side of the filter, the two circuits are not separated from one another but the second side is only short-circuited. The tuning condenser of the second side can also be separated or, what comes to the same thing, the second circuit can be removed in the case of filters coupled by mutual inductance. There is however no change in the asymmetry due to losses in the coupling reactance."

2087. The Use of Cauer's Symmetrical Filter Circuits in the Broadcast Band.—Steffenhagen. (*See* 2135.)

2088. The Graphical Determination of Band-Filter Curves: Corrections.—Stejskal. (*Funktech. Monatshefte*, Feb. 1937, No. 2, p. 55.) *See* 1723 of May.

2089. Graphical Representation of Band-Pass Characteristics.—C. V. Erickson. (*Rad. Engineering*, March 1937, Vol. 17, No. 3, pp. 12–14 and 23: to be contd.)

2090. A Note on the Design of Series and Parallel Resonant Circuits [where Impedance is required to have Given Values at Two Frequencies].—L. E. Q. Walker. (*Marconi Review*, Nov./Dec. 1936, No. 63, pp. 7–11.)

2091. UNIVERSAL PERFORMANCE CURVES FOR TUNED TRANSFORMERS [applicable to Design of R.F. Pre-Selectors, Band-Pass A.F. Filters, and I.F. Circuits].—J. E. Maynard. (*Electronics*, Feb. 1937, Vol. 10, No. 2, pp. 15–18.)

2092. SOME NOTES ON TUNED-COUPLED CIRCUITS.—Aiken. (*Comm. & Broad. Eng.*, March 1937, Vol. 4, No. 3, pp. 5–7 and 30, 31.) Some of the results of the full analysis dealt with in 1719 of May.

2093. THE EVOLUTION OF THE CRYSTAL WAVE FILTER [General Account].—O. E. Buckley. (*Journ. of Applied Phys.* [formerly *Physics*], Jan. 1937, Vol. 8, No. 1, pp. 40–47.)

2094. CURRENT LOCI IN THE GENERAL LINEAR A.C. NETWORK [not excluding Amplifiers].—A. Hazeltine. (*Elec. Engineering*, March 1937, Vol. 56, No. 3, pp. 325–330.)

2095. THE ALTERATION OF THE HARMONICS IN AMPLIFIERS WITH NEGATIVE FEED-BACK.—H. Bartels. (*T.F.T.*, March 1937, Vol. 26, No. 3, pp. 53–54.)

Feldtkeller (4034 of 1936) has shown that the introduction of negative feed-back does *not* produce a reduction of non-linear distortion proportional (as Black gives it approximately) to the decrease in amplification, and that in certain conditions parasitic frequencies may even be generated. The writer now gives a quantitative investigation of the qualitative fact announced by Feldtkeller, that the third harmonic and the third-order combination tones can be increased as well as decreased by weak negative feed-back. He finds that such an increase of third harmonic can only be very small numerically, and is likely to appear only under very unfavourable practical conditions.

2096. DYNAMIC CHARACTERISTICS OF AMPLIFIER VALVES WITH RETROACTIVE COUPLING.—R. Feldtkeller & E. Thon. (*T.F.T.*, Jan. 1937, Vol. 26, No. 1, pp. 1–7.)

Bartels's graphical method of obtaining the non-linear distortion of a retroactively coupled valve is invaluable where a general view is required or large distortion is to be measured. In the region of very small distortions (as in the case of valves for the simultaneous amplification of several carrier-current channels), calculation is more accurate than graphical determination. The writers therefore, starting from the space-charge law between anode current and modulating voltage, derive the " klirr " constants for the 2nd and 3rd harmonics and show how they are affected by positive and negative feed-back and by a varying amplification factor.

2097. METHODS FOR THE REDUCTION OF NON-LINEAR DISTORTION (LINEARISATION).—T. Sturm. (*Funktech. Monatshefte*, March 1937, No. 3, pp. 77–82.)

Author's summary :—" It is shown that the linearisation of triode valves by the introduction of ohmic resistance, and the linearisation by negative feed-back, are capable of similar representation. Both provide a considerable decrease in ' klirr ' factor, accompanied however by a corresponding decrease in amplification factor. Finally a method is given by which the linearisation of r.f. amplifiers also is possible," by a special form of negative feed-back, the degree of modulation of the incoming r.f. being reduced at the input of the r.f. amplifier by the action of an a.c. voltage taken from the l.f. stages ; as in Fig. 11, where H is a r.f. amplifier, D its detector, and S a hexode (in front of the r.f. amplifier) whose amplification is varied in proportion to the distorting voltage by means of a voltage carried from D to its current-distributing grid. Modulators also can be linearised : part of the modulated output voltage is taken off to a linear rectifier G (Fig. 12) and after demodulation is connected in reverse phase in series with the modulation voltage. This method has been adopted in Telefunken transmitters.

2098. PREVENTION OF BLOCKING IN RESISTANCE-CAPACITY COUPLED AMPLIFIERS [Blocking almost always due to First-Stage Grid becoming Positive and passing Considerable Current into Coupling Condenser : Tendency reduced to One-Tenth by Extra Grid Leak in Series with Second-Stage Grid].—O. H. Schmitt. (*Review Scient. Instr.*, March 1937, Vol. 8, No. 3, p. 90.) Typical cases of blocking are in work on nerve action potentials, echo investigations where a weak echo follows a very strong one, and in radio reception with strong static.

2099. LEAKY CONDENSERS IN RESISTANCE-COUPLED AMPLIFIERS [Grid-Bias Variation due to Leakage prevented by Extra Blocking Condenser and Grid Leak in Each Stage].—O. H. Schmitt. (*Review Scient. Instr.*, March 1937, Vol. 8, No. 3, p. 91.) Enabling cheap commercial condensers to give a stability equal to that provided by the finest mica condensers.

2100. TIME DELAY IN RESISTANCE-CAPACITY CIRCUITS [as used with Rectifiers in Volume Expander and AVC Circuits, Noiseless Sound-on-Film Recording, etc : Calculation].—E. W. Kellogg & W. D. Phelps. (*Electronics*, Feb. 1937, Vol. 10, No. 2, pp. 22–24.)

2101. MULTIPLE-CIRCUIT PADS [Charts for Networks matching Several Equal Impedances to One Other of Different Value].—F. Wheeler. (*Electronics*, March 1937, Vol. 10, No. 3, pp. 33–34.)

2102. TWO-TERMINAL EQUALISERS [adding Attenuation and Phase-Shift to improve Network Characteristics].—C. E. Smith. (*Comm. & Broad. Eng.*, March 1937, Vol. 4, No. 3, pp. 10–11 and 31.) The calculation of the series-admittance and shunt-impedance equalisers is given.

2103. DISCUSSION ON " TWO METHODS FOR THE CALCULATION OF VARIABLE RÉGIMES STARTING FROM THE PERMANENT RÉGIMES."—Julia. (*Bull. Soc. franç. des Élec.*, March 1937, Vol. 7, No. 75, pp. 325–328.) *See* 466 of February.

2104. On the Theory of Relaxation Oscillations [in General: Method of Calculation of Amplitude and Period].—J. Haag. (*Comptes Rendus*, 22nd March 1937, Vol. 204, No. 12, pp. 932–934.)

2105. On the Behaviour of Electrical Circuits fed through Rectifiers [Analytico-Graphical Treatment].—A. M. Angelini. (*L'Elettrotec.*, No. 21, Vol. 23, 1936, pp. 660–663.)

2106. An Analysis of Copper-Oxide Rectifier Circuits.—P. O. Huss. (*Elec. Engineering*, March 1937, Vol. 56, No. 3, pp. 354–360 and 366, 367.)

2107. Symmetrical Triode Circuit for Frequency Doubling.—Soc. indépend. Télég. sans Fil. (French Pat. 808 766, pub. 15.2.1937: *Rév. Gén. de l'Élec.*, 27th March 1937, Vol. 41, p. 104D.)

TRANSMISSION

2108. Electron Inertia as the Cause of Harmonics in Valves.—W. E. Benham. (*Nature*, 3rd April 1937, Vol. 139, pp. 591–592.)

A theoretical analysis is given of the motion of electrons in a one-dimensional electric field, which yields "the electron convection current for any periodic total current wave-form. The solution is in terms of the instantaneous electronic transit time, and permits calculation of the n^{th} harmonic in a valve if the transit time is known to the $(n-1)$th order only."

2109. Some Considerations on the Frequency Stability of Ultra-Short-Wave Driving Oscillators.—K. Posthumus & Tj. Douma. (*Philips Transmitting News*, March 1937, Vol. 4, No. 1, pp. 1–14: in English and German.) Continued from No. 4, Vol. 3.

2110. An Ultra-Short-Wave Transmitter Stabilised by means of a Special Highly Resonant Circuit.—Loeb. (*Génie Civil*, 20th March 1937, Vol. 110, p. 277.)

Using a grid stabilising circuit consisting of two cast copper "shells," with their centres joined by a rod and their spacing adjustable, presumably after the style of the American "top hat" "high-Q" circuits (988 of 1935 and back reference): the calculated "Q" was 10 000, the measured value under working conditions was 190—"which is still considerable." An anode-voltage change from 450 to 600 volts gave a frequency variation of some hundreds of cycles per second: the oscillator could thus be modulated directly by anode control. The wave-range originally involved was 3–6 m, but later was increased down to 1.40 m. The shortest waves sometimes suffered absorption by fog. The 3–6 m waves were found to be much more free from ignition interference than waves in the 7–9 m range. In the Discussion, Gantet & Lehmann maintain that ordinary oscillating circuits can be made with "Q" values around 50 to 60; they consider that Loeb's arrangement introduces supplementary losses and reduces resonance.

2111. A 5-Metre Record [G5BY's Transmitter, Croydon: R5 in New York, with Tuned Diamond Aerial].—H. L. O'Heffernan. (*Television*, March 1937, Vol. 10, No. 109, pp. 171–172 and 185.)

2112. Generator Circuit using a Magnetron [Anode Segments across Tuned Oscillating Circuit connected to Resonant Circuit tuned to Twice the Frequency].—K. Fritz: Telefunken. (*Hochf:tech. u. Elek:akus.*, March 1937, Vol. 49, No. 3, p. 105: German Patent 638 761 of 1.2.1935.)

2113. Arrangement for Push-Pull Modulation of a Magnetron with an Anode of at least Two Segments [Modulation Valves in Parallel with Anode-Segment/Cathode-Path in Magnetron].—H. E. Hollmann: Telefunken. (*Hochf:tech. u. Elek:akus.*, March 1937, Vol. 49, No. 3, p. 105: German Patent 638 762 of 22.8.1934.)

2114. An Accurate and Rapid Method for the Measurement of Percentage Modulation.—Soc. indépend. Télég. sans Fil. (French Pat. 808 445, pub. 5.2. 1937: *Rev. Gén. de l'Élec.*, 27th March 1937, Vol. 41, p. 103D.)

2115. What is meant by "Good Modulation"? [Requirements as to Frequency Dependence, Amplitude Dependence, and Background Noise Level].—H. Brückmann. (*T.F.T.*, Feb. 1937, Vol. 26, No. 2, pp. 25–28.)

2116. A Practical Survey of Pentode and Beam Tube Crystal Oscillators for Fundamental and Second Harmonic Output.—J. J. Lamb. (*QST*, April 1937, Vol. 21, No. 4, pp. 31–38 and 106, 107.)

RECEPTION

2117. Reception in the Decimetre-Wave Region [particularly the Present Superiority of Retarding-Field Audions (with or without Super-Regeneration) over Magnetrons: Difficulties of Superheterodyne Reception: Possibilities of "Wobbling" Heterodyne: etc.].—E. C. Metschl. (*Funktech. Monatshefte*, Dec. 1936, No. 12, pp. 443–448.)

Existing valve technique makes superheterodyne reception possible for waves around 50 cm: the indirectly heated SD1 triode can be used as oscillator, the indirectly heated dipole SA1 as mixer; but for shorter waves the method needs further valve development. At present the retarding-field circuit is the only one for waves of 10 cm and under.

2118. A Heterodyne Adaptor Unit for 1.6 m Waves with and without Crystal [Tourmalin] Control.—H. Awender & E. Bussmann. (*Funktech. Monatshefte*, Dec. 1936, No. 12, pp. 441–442.) Using an ACH1 triode-hexode mixing valve, which can generate waves down to 1 m, in a modification of the "three-point" circuit.

2119. Ultra-Short-Wave Quality Receiver [Three-Valve, for A.C. Mains].—(*Wireless World*, 23rd April 1937, Vol. 40, pp. 390–393.)

2120. "FLUTTER" AND "WANDER" IN SHORT-WAVE RECEIVERS.—G. H. Bradbury. (*Wireless World*, 2nd April 1937, Vol. 40, p. 339.)

2121. A METAL-VALVE COMMUNICATION RECEIVER [6-Valve, for A.C. Mains or Car Accumulator: for Tropics and Elsewhere].—J. W. Paddon. (*Television*, March 1937, Vol. 10, No. 109, pp. 166–168: to be contd.)

2122. IMPROVED CAR RECEIVERS [Telefunken Type 3766].—Telefunken. (*Funktech. Monatshefte*, Feb. 1937, No. 2, pp. 52–53.)

2123. A BROADCAST RECEIVER DRIVEN OFF A PARAFFIN LAMP [Successful Exhibit at Leipzig Fair: Heating Current and Anode Supply from Generator (without Commutator or Slip Rings) driven by Hot-Air Motor].—Heinrici. (*Funktech. Monatshefte*, March 1937, No. 3, p. 99.)

2124. "DE LUXE" RECEIVERS IN AMERICA [Comparison of "Masterpiece V" 20-Valve Receiver (12-Valve by German Reckoning) with German Designs].—R. Wigand. (*Funktech. Monatshefte*, Dec. 1936, No. 12, pp. 448–450.)

2125. A PRE-SET TUNER [with "Cash Register" Station Selection].—R. Baker. (*Rad. Engineering*, March 1937, Vol. 17, No. 3, pp. 24–25.)

2126. NEW SHARP TUNING WITH MAGNETIC BRAKING.—E. Schwandt. (*Funktech. Monatshefte*, Feb. 1937, No. 2, pp. 53–55.) *See* also 1756 of May.

2127. ON THE QUESTION OF HIGH-FREQUENCY DETECTION: DETECTOR [Sirutor, etc.], DIODE, AUDION [Leaky-Grid Detector], AND ANODE-BEND DETECTOR.—H. Lamparter. (*Funktech. Monatshefte*, March 1937, No. 3, pp. 89–94.)

The writer considers that in spite of the age of the problem a renewed discussion of it is desirable, taking into special account the working conditions which influence the behaviour (especially as regards distortion) of all four systems. The series and parallel connections of the diode are both dealt with: the treatment of the audion includes the effect of a choke in the anode circuit, and also Nestel's "improved audion" circuit and the similar audion-cum-Sirutor arrangement. *Cf.* Tamm, 1749 of May.

2128. MULTIPLE AND COMBINATION CONTROLS FOR BROADCAST RECEIVERS [Failure of Single Volume Controls owing to Sensitivity Curve of Ear: Dual and Tandem Controls: Combination Controls using Trip Switches: Silent Tuning Devices with Push-In Movement: Rotating-Condenser Controls].—H. C. Riepka. (*E.T.Z.*, 25th Feb. 1937, Vol. 58, No. 8, pp. 207–209.)

"In recent years a certain standardisation has been reached, whereby a volume control of about 10–30 kiloohms max. resistance is introduced into the input of the receiver while a second control, from 0.5–1.0 megohms, controls the low-frequency portion. The use of a dual control device for this purpose is an obvious step, so that in Germany there is hardly a high-class receiver without this construction, whereas in France and England—apparently from lack of good dual-control devices—two separate controls are employed."

2129. VOLUME EXPANSION TECHNIQUE [and a Circuit giving 40 db Additional Contrast without Serious Distortion].—L. A. de Rosa. (*Rad. Engineering*, March 1937, Vol. 17, No. 3, pp. 20, 22.)

2130. CONTRAST EXPANSION [Simple Lamp Method improved by Constant Auxiliary Heating Current].—G. Sayers: Weeden. (*Wireless World*, 16th April 1937, Vol. 40, p. 378.) *See* 506 of February.

2131. SOME NOTES ON THE NATIONAL INDUSTRY IN BROADCAST RECEIVERS AND ITS FUTURE DEVELOPMENT.—G. Fassio. (*L'Elettrotec.*, No. 22, Vol. 23, 1936, pp. 693–694.)

2132. A METHOD OF BROADCAST RECEPTION FREE FROM FADING [Combined Use of Short Vertical and Loop Aerials, with Variable-Mu Screen-Grid Valve to give Phase Shift and Intensity Adjustment].—S. Namba & R. Kimura. (*Journ. I.E.E. Japan*, Oct. 1936, Vol. 56 [No. 10], No. 579, pp. 1028–1032: English abstract pp. 79–80.)

2133. PREVENTION OF BLOCKING IN RESISTANCE-CAPACITY COUPLED AMPLIFIERS, *and* LEAKY CONDENSERS IN RESISTANCE-COUPLED AMPLIFIERS.—Schmitt. (*See* 2098 & 2099.)

2134. A WIDE-BAND TUNER [for High-Fidelity Reception from Local Stations: using Circuits employed in Western Electric 10A Receiver].—W. N. Weeden. (*Electronics*, Feb. 1937, Vol. 10, No. 2, pp. 19–21.) *See* also 1725 of May.

2135. THE USE OF CAUER'S SYMMETRICAL FILTER CIRCUITS IN THE BROADCAST BAND.—K. Steffenhagen. (*Funktech. Monatshefte*, March 1937, No. 3, pp. 85–87.)

In view of present-day requirements of selectivity, the writer urges the use of Cauer's bridge-type filters as the input band-pass filters in broadcast receivers. The special type recommended is that shown in Fig. 5, equivalent circuit Fig. 4, which is dealt with in Glowatzski's paper (1934 Abstracts, p. 50: *see* also G.W.O.H., same Abstracts, p. 381); the complete circuit, with its 1 : 1 r.f. transformer and the impedances R, R across the input and output, is seen in Fig. 6, and the diagram of the whole receiver input circuit in Fig. 7, where the matching transformers before and after the filter are shown. The values of the various L, C elements of the filter circuit have been worked out in full for 10 important German stations, with the aid of calculating machines, and the final values are given in the table at the end of the article. For all 10 stations the terminating impedance R is either 25 or 50 ohms. Apart from this, each station is given a filter of its own, since although the design of a variable type is possible it presents practical difficulties; a later paper will deal with this problem.

2136. A NEW I.F. COUPLING SYSTEM FOR SUPERHET RECEIVERS: AN EFFICIENT ELECTRO-MECHANICAL FILTER-TRANSFORMER OF HIGH SELECTIVITY.—J. J. Lamb: Brush Development Company. (*QST*, April 1937, Vol. 21, No. 4, pp. 28–30.)

The Brush "Transfilter" consists of a small steel rod with four very small Rochelle-salt plates secured to it near its centre: two of these, in parallel, are used as driver elements, the other two as output elements. The use of the steel bar reduces the usually large temperature-effect of Rochelle salt to such an extent that the frequency drift of the Type A model is only about 100 cycles per million per degree Centigrade.

2137. BAND FILTER WITH VARIABLE BAND WIDTH FOR WIRELESS RECEIVERS [with Two Additional Coils coupled to Band Filter Coils: Variable Width obtained by switching Them over].—F. Below: Philips Patent Co. (*Hochf:tech. u. Elek:akus.*, Feb. 1937, Vol. 49, No. 2, p. 71: German Patent 636 591 of 27.7.1935.)

2138. PAPERS ON BROADCAST-BAND AND OTHER FILTERS.—Baumgartner, Alsleben, Maynard, Aiken, Buckley. (*See* 2085/6 and 2091/3.)

2139. THE QUANTITATIVE REQUIREMENTS REGARDING SELECTIVITY IN BROADCAST RECEIVERS, PARTICULARLY SINGLE-CIRCUIT RECEIVERS NEAR THE LIMIT OF THE SERVICE ZONE [and the Inadequacy of Such Receivers to give the 100 : 1 Signal/Noise Ratio].—R. Moebes. (*T.F.T.*, March 1937, Vol. 26, No. 3, pp. 59–62.)

2140. THE LENGTH OF THE FREE AIR WIRE AND ITS RELATION TO SIGNAL VOLTAGE IN SCREENED-DOWNLEAD INSTALLATIONS.—Bergtold. (*See* 2150.)

2141. TESTING A RECEIVER CHASSIS FOR ELECTROSTATIC EXPOSURE [for Quantitative Data for FCC Inquiry].—E. T. Dickey. (*Rad. Engineering*, Feb. 1937, Vol. 17, No. 2, pp. 12–13 and 14.)

2142. A CONTRIBUTION TO THE FLASH-OVER PROBLEM [of Insulators].—H. Eisler. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 18, 1937, pp. 33–35.)

Many researches have shown that with a uniform field and with the most careful elimination of all disturbing secondary influences the air-breakdown potential is the same as the flash-over potential. But the actual conditions of a pin-type insulator correspond more closely to a strongly inhomogeneous field such as that of a parallel-wire-and-plate arrangement, with which the flash-over potential is less than the air-breakdown potential even if the insulator is as clean as in the uniform-field tests. The present researches on insulators placed between rod and sphere electrodes (replacing the parallel-wire-and-plate system) confirm the hypothesis that the difference between the two potentials is due to the attachment of charges to the surface of the insulator. This difference cannot be entirely eliminated by changes in material or shape of the insulator, though it is advantageous to make the projection of the insulator surface, normal to the lines of force, as small as possible in the neighbourhood of the pin. But by influencing the formation and distribution of the space charges, *both* potentials (for a given electrode gap) can be increased: thus when, as in Fig. 5, the rod-and-sphere system was supplemented by a thin wire (1) parallel to, and at the same potential as, the rod, the air-breakdown potential was increased from 68.2 to 86 kv.

2143. "THE CHARACTERISTICS AND PERFORMANCE OF APPARATUS FOR THE MEASUREMENT OF RADIO INTERFERENCE" [Book Review].—British Standards Institution. (*Wireless World*, 16th April 1937, Vol. 40, p. 369.)

2144. AN ELECTRONIC-TYPE OSCILLOGRAPHIC FREQUENCY-RESPONSE CURVE APPARATUS OF WIDE APPLICATION [particularly for Alignment of Broadcast Receivers: Curves up to 50 kc/s Wide at Any Mean Radio or Audio Frequency from 0 to 20 Mc/s: Frequency-Sweep Oscillator using Cabot's "Resistance Tuning"].—W. G. Gordon & A. H. Mutton. (*Journ. I.E.E. Australia*, Feb. 1937, Vol. 9, No. 2, pp. 68–73.)

The linear frequency base here described is entirely non-mechanical (unlike previous methods discussed at the beginning of the paper) and can be synchronised with any existing time base, preferably linear, of any type of oscillograph—c-r, string, or crystal. The frequency sweep is obtained by varying the "resistance tuning" of the patented sweeping oscillator (Gordon & Makinson), part of whose tuning resistance is made up of the internal resistance of a 6C6 pentode working on the negative resistance portion of the characteristic and giving a linear resistance-change with grid bias. At 275 kc/s, one volt change produces about 50 kc/s frequency variation. For Cabot's work on resistance tuning *see* 1934 Abstracts, p. 497.

2145. I.F. TRANSFORMER ALIGNMENT [using Cathode-Ray Oscillograph: "Midwest Radio" Technique].—R. Nathan. (*Electronics*, Feb. 1937, Vol. 10, No. 2, pp. 33 and 71.)

2146. STANDARD TESTS FOR RADIO RECEIVERS. IV—THE OVER-ALL RESPONSE: V & VI—ERRORS IN ACOUSTIC MEASUREMENTS.—(*Electrician*, 19th & 26th March and 2nd April 1937, Vol. 118, pp. 386–387, 419–420, and 461–462.) *See* also 1781 of May.

2147. A CONDENSER-TRACKING TEST SET [with Automatic Visual and Aural Indication when Condenser differs by More than 0.01 $\mu\mu$F].—J. L. Roemisch. (*Electronics*, March 1937, Vol. 10, No. 3, pp. 12–15.)

2148. PLASTIC CASES FOR TABLE RADIOS.—Brill. (*Rad. Engineering*, March 1937, Vol. 17, No. 3, pp. 10–11.)

AERIALS AND AERIAL SYSTEMS

2149. A NOTE ON LAGUERRE POLYNOMIALS [occurring in Problems of Reflection of Acoustic and Electromagnetic Waves at Paraboloidal Surfaces].—W. T. Howell. (*Phil. Mag.*, April 1937, Series 7, Vol. 23, Supp. No. 156, pp. 807–811.)

2150. AERIAL DIMENSIONS AND AERIAL VOLTAGE: THE LENGTH OF THE FREE AIR WIRE AND ITS RELATION TO THE AVAILABLE SIGNAL VOLTAGE IN SCREENED-DOWNLEAD INSTALLATIONS.—F. Bergtold. (*Funktech. Monatshefte*, Feb. 1937, No. 2, pp. 46–49.)

"Over and over again the strange opinion is encountered that the available signal voltage of an aerial system depends chiefly on the vertical extent of the unscreened part of the aerial." Reasons for this erroneous idea are given, and the true picture of the system is drawn, from which it is seen that even an aerial without any appreciable unscreened vertical component, but with a free horizontal part l, must take up a voltage which in principle increases with the height h of this part above ground. If h and l are kept constant and a, the screened-lead length, is varied, an increase of a means (1) an increase in cable capacity; this acts as a load and decreases the available voltage: (2) a decrease in the capacity of the free aerial, also decreasing the available voltage: and (3) an increase of the height of the mid-point of the free part, giving an increase of available voltage; this increase, however, is small compared with the decreases (1) and (2). Thus an increase of the screened length always decreases the available voltage, the more so, the smaller the ratio of horizontal free part to the height h. Fig. 9 shows the available voltage for an aerial of fixed over-all height of 10 m, as a function of the screened length of downlead, up to 10 m: the four curves refer to aerials with 20, 10, 5, and 0 metres of horizontal extension (Fig. 10). Fig. 11 shows that with the vertical downlead completely covered ($a = 10$) and horizontal extensions of about 6 m and upwards, the use of two suitable transformers gives available voltages (curve 3) little less than those given by a completely unscreened system without transformers (curve 1).

2151. DETERMINATION OF THE CAPACITY OF AERIAL SYSTEMS [by the Immersion of Small-Scale Model in Badly Conducting Electrolyte in Metal Tank, and Measurement of Resistance between Model and Tank].—F. Bergtold. (*Funktech. Monatshefte*, March 1937, No. 3, pp. 88–89.)

The conversion of resistance value into capacity value is carried out by using an easily calculated system (such as a sphere) as a reference model. Usually, however, it is only desired to *compare* different aerial systems. The tank should be so large that the smallest liquid distance between model and walls is not less than about three-quarters of the largest dimension of the model. The thickness of the aerial wires cannot be represented accurately to scale, but calculations show that no noticeable error in capacity is thus introduced.

2152. THE MARCONI FOLDED TOP AERIAL FOR MEDIUM WAVES [Radiation Resistance due to Horizontal Part of T Aerial, Useless for Direct-Ray Communication, almost completely Suppressed].—N. Wells. (*Marconi Review*, Nov./Dec. 1936, No. 63, pp. 19–21.)

Successfully used at Viipuri (Finland) and Jerusalem.

2153. THE INFLUENCE OF UNEVEN GROUND IN THE NEIGHBOURHOOD OF AN ANTI-FADING AERIAL ON THE VERTICAL RADIATION DIAGRAM.—H. Brückmann. (*T.F.T.*, Jan. 1937, Vol. 26, No. 1, pp. 7–10.)

The writer concludes that for an anti-fading aerial with a zero angle of about 60°, and an equivalent height (height of a very small equivalent dipole) of 130 metres, it is sufficient if the land is flat and level over a radius of 100 metres round the foot of the aerial. For steeper zero angles or lower aerials this radius can be decreased, while for flatter angles or higher aerials it must be increased.

2154. DIRECTED VERTICAL RADIATION WITH DIAMOND ANTENNAS: 14 Mc/s RHOMBIC SYSTEMS WITH STEERAGE CONTROL TO SUIT TRANSMISSION CONDITIONS.—M. E. Moore & F. L. Johnson. (*QST*, April 1937, Vol. 21, No. 4, pp. 21–24 and 51.)

2155. TRANSMITTING AERIALS.—E. Siegel & J. Labus. (*Hochf:tech. u. Elek:akus.*, March 1937, Vol. 49, No. 3, pp. 87–94.)

For previous work *see* 1934 Abstracts, p. 502. Here, formulae are first found (§ II) for the current, voltage, reactance and impedance at the bottom of an aerial excited there. These are compared with measured values (Figs. 1–3). The wavelengths along the aerial and in air are discussed (§ III). Deviations of the formulae of § II from the measured values are found to be due to the difference between the lengths of a standing wave of constant frequency in air and along the aerial. Adjustment of the scale of Fig. 3 for the shortening of wavelength along the aerial gives better agreement (Fig. 6). It follows that the usual characterisation of an aerial by the quantity (height)/(wavelength in air) has no physical meaning; the aerial properties must be determined by the "electrical height," (height)/(wavelength along aerial). In § IV the field at the earth's surface is calculated; the undesirable effect of the quantity (radiation resistance)/(distance along aerial) on the high-angle radiation is deduced (§ V). "It is pointed out that, in order to ensure sinusoidal current distribution along an aerial for which (height) (wavelength) is greater than 0.5, it should not be fed at the bottom but at a point above the current node."

2156. APPLICATIONS OF CONCENTRIC TRANSMISSION LINES.—V. J. Andrew. (*Electronics*, March 1937, Vol. 10, No. 3, pp. 40, 43, 44.)

VALVES AND THERMIONICS

2157. ELECTRON GAS IN A MAGNETIC FIELD.—E. Lifschitz. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 11, 1937, pp. 141–156: in German.)

Application of the work of Landau (1254 of March) to a gas, containing particles of charge e and mass m, in a homogeneous magnetic field H. The kinetic equation is derived, giving the distribution function of the particles. With the help of this equation the writer calculates the relaxation time for the establishment of static equilibrium of the particle velocities—that is, the time necessary for the setting up of the Maxwellian equilibrium. The relaxation times for the velocities perpendicular and

parallel to the magnetic field are shown to be different: the former is given by eqn. 18, the latter by eqn. 19: it is seen that the equilibrium as regards the velocities perpendicular to the field is set up more rapidly than that for the velocities parallel to it: thus if H is about 1000 gauss, T (temperature) about 10 000°, and ν (number of particles in unit volume) about 10^8 per cm^3, the "perpendicular" relaxation time is about 10^{-3} sec. and the "parallel" about 10^{-2} sec.

The thermal conductivity of such a gas is determined (eqn. 28). It is found that equilibrium in temperature is obtained more quickly than equilibrium in density. A cylindrical beam of charged particles in the direction of the magnetic field is considered. Such a ray is thickened by Coulomb interaction: the relation of thickness to time is given by eqn. 31. A similar relation, for a flat ray, is given by eqn. 32.

2158. Dielectric Constant of an Electronic Atmosphere for Ultra-Short Waves.—Imam & Khastigir. (*See* 2055.)

2159. Resonance Dispersion in Ionised Gases.—Sigrist. (*See* 2054.)

2160. A Spectroscopic Study of the Magnetron Discharge.—Luhr & Studer. (*See* 2412.)

2161. On the Generation of Ultra-Short Waves by the Spiral-Anode Magnetron.—Uchida & Sekimoto. (*Journ. I.E.E. Japan*, Nov. 1936, Vol. 56 [No. 11], No. 580, p. 1184: Japanese only.)

2162. New Transmitting Valves of High Output for Centimetre Waves [Cathode-Ray from Concave Cathode passes through Tube Electrode (connected to Tuned Circuit) between Disc Accelerating Electrodes].—(*Funktech. Monatshefte*, Dec. 1936, No. 12, pp. 466–467.)

With the push-pull form of this valve, "efficiencies of 35% can be obtained even on decimetre waves." For a 10 000-volt tube the mean anode current is 50 mA: output power 100–140 watts. The illustrations are diagrammatic only, no constructional details being given.

2163. Metal Valve for Generation of Micro-Waves, with Wavelength Variable by Micrometer-Screw Adjustment of Gap.—J. Pintsch Company. (French Pat. 808 567, pub. 10.2.1937: *Rev. Gén. de l'Élec.*, 27th March 1937, Vol. 41, pp. 103–104D.)

2164. The Acorn Tube [Type 955] in Portable Pre-Amplifiers for Remote-Control Work.—W. E. Stewart. (*Comm. & Broad. Eng.*, Feb. 1937, Vol. 4, No. 2, pp. 9 and 19.)

2165. Micro-Waves: Part VI—Valves.—Carrara. (*Alta Frequenza*, March/April 1937, Vol. 6, No. 3/4, pp. 222–229.) For previous parts *see* 2058, above.

2166. Power Amplification at Micro-Wave Frequencies and the Limit of Retroaction Oscillations.—H. Zuhrt. (*Hochf:tech. u. Elek:akus.*, March 1937, Vol. 49, No. 3, pp. 73–87.)

In previous papers (2616 of 1936) the general equations for the current and voltage in a triode with negative bias were deduced. Here, exact (§ 1B) and approximate (§ 1C) expressions for the valve constants are deduced from them and shown graphically in Figs. 5–7, the transit time of the electrons being considered. Equivalent circuits (Figs. 2a, b, c) for the valve in various connections are first found by considering it as a quadripole (Fig. 1). From these, the voltage amplification and input impedance of the valve are calculated (§§ II, III) and compared with measurements of other writers (Table I, Figs. 10, 11). A physical explanation of the existence of a positive real part of the grid current is given (Fig. 9). The magnitude and limit of the power amplification is evaluated in § IV; a condition (eqn. 81a) for the retroaction is found which takes into account all internal and external energy losses. It agrees with eqn. 68a, which gives the limit of power amplification for phase-free voltage amplification. Eqn. 86 gives the general condition for the existence of retroaction oscillations for arbitrary external resistances; the optimum condition is given by eqn. 88a. Fig. 12 shows the limit of retroaction oscillations. Numerical evaluations of the theory are given, with an approximate formula (eqn. 90a), for two practical cases, and are found to agree well with observed values.

2167. The Space-Charge Equation for Electrons with Initial Velocity: Part II.—W. Kleen & H. Rothe. (*Zeitschr. f. Physik*, No. 11/12, Vol. 104, 1937, pp. 711–723.)

For I *see* 3772 of 1936. In the present paper "current/voltage characteristics are calculated for a system of plane parallel electrodes, into which electrons enter with homogeneous initial velocity normal to the electrodes. It is found that formation and dissolution of the virtual cathode are connected with discontinuous changes in the current or potential distribution. The characteristics have, in part, branches of negative resistance of arc or dynatron type."

2168. Characteristics of Transmitting Tubes [Triodes, Tetrodes, and Pentodes: Chart with μ as Ordinates, G_m as Abscissae, giving R_p on Diagonals].—J. G. Sperling. (*Comm. & Broad. Eng.*, Feb. 1937, Vol. 4, No. 2, p. 18.)

2169. The Control Process of the Triode Valve [with Field Diagrams and Potential Reliefs, etc.].—H. Gottmann. (*Funktech. Monatshefte*, Dec. 1936, No. 12, pp. 457–461.) For previous work *see* 1794 of 1936.

2170. A New Time Base using a Triode Gas-Filled Relay Tube [Philips Type 4686, giving Frequencies up to 50 kc/s instead of Usual Relay-Tube Limit of 10 kc/s].—Hughes. (*Toute la Radio*, April 1937, No. 39, Supp. pp. 203–207.)

2171. Movable-Anode Tubes [Experimental All-Metal Diodes giving 7.0 mA Anode-Current Change for 0.001 Inch Motion at 1 Inch from Tube: for Extensometer, Pressure Indicator, Pick-Up, etc.].—E. D. McArthur. (*Electronics*, March 1937, Vol. 10, No. 3, pp. 16–17.)

2172. PENTODE AND BEAM TUBES AND THEIR USE WITH CRYSTAL OSCILLATORS.—Lamb. (*See* 2116.)

2173. NEW RECEIVING TUBES [chiefly " G " Type ; being Duplicates, in Octal Bases, of Existing Valves].—(*QST*, April 1937, Vol. 21, No. 4, pp. 55 and 122.)

2174. NUMBERING TUBES [Present System of Valve Classification and Numbering is now Meaningless : Suggested New Scheme].—(*Rad. Engineering*, March 1937, Vol. 17, No. 3, pp. 5–6.)

2175. A NEW MULTI-COMPONENT RECORDER FOR CHARACTERISTIC CURVES [of Valves, Transmitters, etc.].—H. Awender & D. M. Tombs. (*Funktech. Monatshefte*, March 1937, No. 3, pp. 94–97.)

An example of the multiple action is seen in Fig. 8, a record showing the variation of the anode current of a diode with the heating current and the d.c. anode voltage. Fig. 7, a record of a push-pull ultra-short-wave oscillator, shows the relation between the heating current, anode voltage, anode current and r.f. output (represented by the rectified current $I_{h.f.}$ measured in an aperiodically coupled detector circuit). The writers' method of recording 3 or 4 variables on a two-dimensional rectangular-coordinate diagram can best be understood from Fig. 1, where, starting from the ordinary curve of 2 variables, it is seen that a third variable can be represented by spines of varying length emerging from closely adjacent points along this curve, all the spines being parallel to one another and representing, in length, the values of the third variable. If these third-variable spines proceed upwards from the curve, a fourth variable may be represented by a second set of spines sloping downwards from the original curve (actually at right angles to the first set). The elaborate system of separate meters with attached mirrors or optical shutters (working in conjunction with fixed slits), lenses, right-angled prisms, etc., by which such multiple records are made, is seen in Fig. 2. A single " Kinox " lamp provides the necessary light.

2176. A DYNAMIC METHOD OF PLOTTING THE CHARACTERISTICS OF VALVES [using Short Rectangular Voltage Waves and D.C. Instruments].—L. Pajetta. (*Alta Frequenza*, March/April 1937, Vol. 6, No. 3/4, pp. 156–164.) Using a two-pentode circuit, due to Vecchiacchi, for producing the rectangular pulse.

2177. GRAPHICAL ESTIMATION OF THE SIGNAL-HANDLING CAPACITY OF SCREEN-GRID VALVES.—R. W. Sloane. (*Phil. Mag.*, April 1937, Series 7, Vol. 23, No. 155, pp. 529–534.)

If $i = f(v)$ represents the anode current of a carrier-frequency amplifying valve as a function of grid-voltage only, and g is the mutual conductance of the valve, an experimental curve of g against v can be plotted experimentally. By the graphical method described this curve will give the peak value of a sinusoidal variation of v, modulated to a depth m, which will produce an output current containing a given percentage of second harmonic of the modulation. The method is very useful if its limitations are respected. It applies also to frequency changers.

2178. " ANLEITUNGEN ZUM ARBEITEN IM RÖHRENLABORATORIUM " [Vacuum Laboratory for Research on Valves, etc : Book Review].—M. Knoll. (*Electrician*, 9th April 1937, Vol. 118, p. 486.)

2179. THE FIELD DISTRIBUTION SURROUNDING A CONDUCTOR-CORE COIL.—Ohtaka & Mano. (*Journ. I.E.E. Japan*, Dec. 1936, Vol. 56 [No. 12], No. 581, p. 1246 : Japanese only.)

2180. VARIATION OF THE SECONDARY ELECTRON EMISSION OF SOME METALS WITH THE ANGLE OF INCIDENCE OF THE PRIMARY CATHODE-RAY BEAM [Experimental Curves showing Continuous Increase in Secondary Emission with Obliquity of Incidence : Theoretical Explanation : Effect of Density of Metal].—H. O. Müller. (*Zeitschr. f. Physik*, No. 7/8, Vol. 104, 1937, pp. 475–486.)

2181. SOME DATA ON THE QUESTION OF THE RELATION BETWEEN SECONDARY ELECTRON EMISSION AND PHOTOSENSITIVITY.—Dobrolyubski. (*See* 2287.)

2182. ELECTRONIC SELF-PORTRAITS [showing Progress of Activation in Thoriated Tungsten, and Other Effects].—Johnson & Shockley. (*Electronics*, March 1937, Vol. 10, No. 3, pp. 22–23.) Using the simple electron microscope dealt with in 2201 of 1936.

2183. THE NORMAL CATHODE DROP AT SINGLE-CRYSTAL SURFACES OF DIFFERENT ORIENTATION : I [Measurements at Surfaces of Bi Crystal in Gas Discharge in Argon].—H. Kurzke. (*Zeitschr. f. Physik*, No. 11/12, Vol. 104, 1937, pp. 735–743.) *See* also 3424 of 1936.

2184. THE MECHANISM OF ELECTRON EMISSION FROM COATED CATHODES [Qualitative Explanation in Terms of Fundamental Quantum-Mechanical Ideas].—E. Meschter. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, pp. 377–378 : abstract only.)

2185. POTENTIAL ATTAINED BY INSULATORS WHEN BOMBARDED BY ELECTRONS.—Hagen & Bey. (*See* 2341.)

DIRECTIONAL WIRELESS

2186. ERROR-FREE BEARINGS WITH THE PULSE DIRECTION-FINDING APPARATUS : SUPPLEMENTARY NOTE.—Diefenbach : Telefunken. (*Funktech. Monatshefte*, Feb. 1937, No. 2, p. 55.)

See 1823 of May. " In Germany the system was first proposed, and the fundamental work carried out, by Dr. Plendl at the DVL. As a result of this work the Telefunken impulse d.f. equipment Spez. 2036N (German Pat. 592 440) was constructed."

2187. S.F.R. Night Radiogoniometer, "Brief Signals" System [with Cathode-Ray Tube Reception of "Ticker" Signals of 1/600th Sec. Duration spaced 1/60oth Sec.].—P. Nicolas. (*Bull. de la S.F.R.*, No. 1, Vol. 10, 1936, pp. 19–30.)

2188. Ultra-Short-Wave Radio Landing Beam. —R. Elsner & E. Kramar: Lorenz Company. (*Comm. & Broad. Eng.*, March 1937, Vol. 4, No. 3, pp. 12–16.)

2189. Vertical Radio Marker Beam [75 Mc/s "Z Marker"].—(*Comm. & Broad. Eng.*, March 1937, Vol. 4, No. 3, p. 2.)

2190. An Aircraft Radio-Compass [RCA Model AVR-8].—E. D. Blodgett & E. T. Dickey. (*Comm. & Broad. Eng.*, Jan. 1937, Vol. 4, No. 1, pp. 14–16.)

2191. Method of Switching Directional Aerials [in Morse Rhythm: Order of Switching from Vertical to Frame Aerial to Avoid Noise Production].—Lorenz Company. (*Hochf:tech. u. Elek:akus.*, March 1937, Vol. 49, No. 3, p. 106: German Patent 637 690 of 16.7.1935.)

ACOUSTICS AND AUDIO-FREQUENCIES

2192. A New Technique for the Demonstration and Investigation of Nerve Action Currents and Other Short-Time Phenomena [*e.g.* Building-Up Processes in Acoustics].—W. Schmitz. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 18, 1937, pp. 37–38.)

The usual saw-tooth time-base method not only demands a number of supply sources and several valves, but also leads often to over-exposure of the zero and final points of the record and provides no zero line. These defects are absent from the writer's arrangement, in which current from a.c. mains, approximately sinusoidal (the wave-form is improved by a resistance-capacity combination), is used to provide both the time-base deflection and the exciting current for the nerve—or, in the acoustic application, the exciting current (then amplified) for the loudspeaker. The excitation being arranged to take place just after the sine-wave maximum, a length of curve, approximately proportional to time and corresponding to a few thousandths of a second, is available for the time base.

For the exciting current, the a.c. is rectified by a diode R (Fig. 1): across the small inductance Dr in the rectifier circuit a "make" voltage of very short duration occurs at each start of a half-wave, and a very short "break" voltage at each ending. Any oscillations tending to occur can be damped out by a parallel resistance. These two voltage pulses, of opposed sense, can be separated from each other by two other rectifiers, Gl_I and Gl_{II}. The selected pulse is isolated from the mains by means of an insulating transformer, to which it is fed by a potentiometer, and is then available for excitation purposes: its shape is seen in Fig. 2. With this plan, and with proper adjustment of the phase displacement between the exciting pulse and the time-base curve, it can be arranged that when (for instance) the screen spot is moving from left to right, at an exactly defined point the exciting pulse occurs, whereas on the return stroke the second pulse is blocked by the second rectifier, so that the spot marks out a zero line. A normal nerve will take 50 excitations in a second, reacting to these with great regularity and completing its action in a few thousandths of a second. With the arrangement described a stationary picture of the action currents can be obtained, complete with its zero line, with a stability hitherto only realised with continuous periodic phenomena. Fig. 5 shows an application to acoustical measurements—a record of the decay of the microphone current of a loudspeaker/air/microphone combination.

2193. A Method of Investigating the Transient Characteristics of Electrical Circuits. —Morse. (*See* 2084.)

2194. Automatic Recording of Audio-Frequency Characteristics [by the "Audiograph"].—Tobe Deutschmann Corporation. (*Rad. Engineering*, Feb. 1937, Vol. 17, No. 2, pp. 20–21.)

2195. A Simple Transmission Measuring Equipment.—L. E. Ryall & A. G. Burgess. (*P.O. Elec. Eng. Journ.*, April 1937, Vol. 30, Part 1, pp. 52–55.)

2196. An Acoustic Impedance Bridge [consisting of Ratio Arm Tubes terminated by Known Reactance Standard and Unknown Impedance respectively: Balance indicated by Differential Microphone].—N. W. Robinson. (*Phil. Mag.*, April 1937, Series 7, Vol. 23, Supp. No. 156, pp. 665–681.)

2197. A Scale for the Measurement of the "Psychological Magnitude" Pitch [taking Loudness into Account].—Stevens, Volkmann, & Newman. (*Journ. Acoust. Soc. Am.*, Jan. 1937, Vol. 8, No. 3, pp. 185–190.) Prompted by Fletcher's proposal that pitch should be specified in terms of a reference tone, at a loudness level of 40 db, which is perceived as equal to the given tone in pitch (*see* 1499 of 1935.)

2198. The Direct Measurement of Phase in Acoustics.—Z. Carrière. (*Revue d'Acoustique*, Fasc. 1/2, Vol. 5, 1936, pp. 1–23.)

2199. Study of Very Weak Noises [by Ear and Movable Reinforcing-Disc Method, for Sounds below Threshold of Microphones]. —F. Canac. (*Revue d'Acoustique*, Fasc. 3/4, Vol. 5, 1936, pp. 81–98.)

2200. The Non-Linear Distortion of Long Telephonic Circuits in Cable, and Its Effect on Intelligibility.—F. G. Lüschen. (*Ann. des Postes, T. et T.*, March 1937, Vol. 26, No. 3, pp. 226–248.)

2201. Discussion on "The Present Position of the Technique of Long-Distance Subterranean Telephone Lines."—L. Simon: Brillouin. (*Bull. Soc. franç. des Élec.*, March 1937, Vol. 7, No. 75, pp. 329–330.)

2202. MUSICAL TRANSMISSION OVER LINES [with Data on Italian Circuits].—G. Castelnuovo. (*L'Elettrotec.*, No. 6, Vol. 24, 1937, pp. 162–171.)

2203. METHODS FOR THE REDUCTION OF NON-LINEAR DISTORTION (LINEARISATION).—Sturm. (*See* 2097.)

2204. BALANCED AMPLIFIERS: PART VII.—Preisman. (*Comm. & Broad. Eng.*, Jan. 1937, Vol. 4, No. 1, pp. 8–9 and 16, 24.) Concluding part of the series referred to in 169 of January.

2205. INVERSE FEEDBACK APPLIED TO THE SPEECH AMPLIFIER FOR THE AMATEUR 'PHONE TRANSMITTER [125 W Output from Two RK39 Valves].—J. B. Carter. (*QST*, April 1937, Vol. 21, No. 4, pp. 46–51.)

2206. RESISTANCE-COUPLED AMPLIFIER DATA [Circuit Values for Use with Various Triodes and Pentodes].—RCA Radiotron. (*Electronics*, Feb. 1937, Vol. 10, No. 2, pp. 29–30.)

2207. EFFECTIVE RESISTANCE-COUPLED AMPLIFICATION WITH PENTODE (SCREEN-GRID) VALVES [such as RENS 1284: Losses involved in Frequency Correction of Microphones, etc., made up by High Working Voltage and Anode Resistance].—K. Thiele. (*Funktech. Monatshefte*, Dec. 1936, No. 12, pp. 451–453.)

2208. A SIMPLE WAY OF INVESTIGATION AND SPECIFICATION FOR MICROPHONES [and Telephones].—K. Hohage. (*Zeitschr. f. Fernmeldetech.*, No. 1, Vol. 18, 1937, pp. 5–7.)

Free from the defects of the C.C.I. comparative method. The microphone is treated as a generator, and it is seen that its properties can be specified adequately by the measured values of e.m.f. and internal resistance as functions of working conditions, especially frequency. Slope S and "durchgriff" D, analogous to those of a valve, are important quantities which can be obtained from the curves.

2209. HORN-LOADED MC LOUDSPEAKERS [Correspondence].—(*Wireless World*, 16th April 1937, Vol. 40, p. 383.) Continued from previous issues.

2210. ROCHELLE SALT OSCILLATOR WITH VIBRATING STEEL BAR, *and* EXPERIMENTS ON PIEZO-ELECTRIC OSCILLATIONS WITH ROCHELLE SALT CRYSTALS.—Lamb: Hiltscher. (*See* 2318 & 2319.)

2211. THE "MAGIC VOICE" LOUDSPEAKER [with Rigidly Sealed Cavity enclosing Back, Back-Wave transferred to Front with Phase Reversal by Five Metal Pipes].—Caulton, Dickey, & Perry. (*Rad. Engineering*, Oct. 1936, Vol. 16, No. 10, pp. 8–10 and 22.)

2212. EQUIPMENT AND METHODS USED IN ROUTINE MEASUREMENTS OF LOUDSPEAKER RESPONSE.—S. V. Perry. (*Rad. Engineering*, March 1937, Vol. 17, No. 3, pp. 7–9: to be contd.)

2213. THE FREQUENCY OF TRANSVERSE VIBRATION OF A LOADED FIXED-FREE BAR: III—THE EFFECT OF THE ROTATORY INERTIA OF THE BAR [Theory].—R. M. Davies. (*Phil. Mag.*, April 1937, Series 7, Vol. 23, No. 155, pp. 563–573.) *See* also 1838 of May.

2214. A NOTE ON LAGUERRE POLYNOMIALS [occurring in Reflection at Paraboloidal Surfaces].—Howell. (*See* 2149.)

2215. A NEEDLE-SCRATCH FILTER WITH MULTIPLE-CAM SWITCHING.—J. Kessler. (*Funktech. Monatshefte*, Dec. 1936, No. 12, pp. 463–466.)

2216. "THE GRAMOPHONE RECORD" [Book Review].—H. C. Bryson. (*Comm. & Broad. Eng.*, Feb. 1937, Vol. 4, No. 2, p. 20.)

2217. THE OFFSET-HEAD CRYSTAL PICK-UP [and Its Reduction of Tracking-Error].—J. R. Bird & C. M. Chorpening. (*Rad. Engineering*, March 1937, Vol. 17, No. 3, pp. 16–18.)

2218. A RECORD-SAVING PICK-UP ["Needle-Tilt" Principle reduces Change in Tracking Angle].—R. P. Glover: Baumzweiger. (*Electronics*, Feb. 1937, Vol. 10, No. 2, pp. 31–32.)

2219. AN INSTANTANEOUS RECORDING HEAD.—G. J. Saliba. (*Comm. & Broad. Eng.*, March 1937, Vol. 4, No. 3, pp. 8–9 and 16, 25.)

2220. A NEW TESTING APPARATUS FOR TELEPHONE EQUIPMENT [using a Sound Generator consisting of Steel Balls falling from Reservoir and deflected to strike a Mica Membrane: Frequency Spectrum uniformly covers Speech Frequencies].—G. H. Domsch & O. Böhm. (*T.F.T.*, March 1937, Vol. 26, No. 3, pp. 49–53.)

2221. CLOSE-MIKE *versus* REVERBERATORY MONITORING [for Sound-Film Recording].—C. Felstead. (*Comm. & Broad. Eng.*, Jan. 1937, Vol. 4, No. 1, pp. 12–13.)

2222. VDE TELEPHONIC CONFERENCE FROM 33 DISTRICTS [with Total Line Length of 7000 km].—(*Funktech. Monatshefte*, March 1937, No. 3, pp. 98–99.)

2223. INSIDE PUBLIC-ADDRESS INSTALLATIONS.—J. P. Taylor. (*Comm. & Broad Eng.*, March 1937, Vol. 4, No. 3, pp. 17–20 and 23, 25.)

2224. THE SOUND EQUIPMENT OF THE GERMAN OPERA HOUSE, BERLIN.—A. Mainka. (*Funktech. Monatshefte*, Dec. 1936, No. 12, pp. 469–473.)

2225. NEW INSTALLATIONS FOR ACOUSTIC PICK-UP AT THE POSTE PARISIEN [including the Roux, Gamzon, Sollima, & Sarnette Three-Register System of Electrical Reverberation Control, and the Lakhovsky "Microstéréophone" Microphone].—M. Adam. (*Génie Civil*, 3rd April 1937, Vol. 110, No. 14, pp. 309–312.) *See* also Aisberg, 1419 of April.

2226. THE OPTIMUM REVERBERATION OF SMALL ROOMS. — G. von Békésy. (*Revue d'Acoustique*, Fasc. 5/6, Vol. 5, 1936, pp. 145–182.)

2227. PROPAGATION OF SOUND IN BUILDINGS [Summarising Account of Recent Practical and Theoretical Work].—K. W. Wagner. (*E.N.T.*, Feb. 1937, Vol. 14, No. 2, pp. 49–66.)

2228. REVERBERATION-TIME CALCULATIONS [with Curves based on Eyring's Formula].—A. J. Ebel. (*Comm. & Broad. Eng.*, Feb. 1937, Vol. 4, No. 2, pp. 10–11 and 16.)

2229. PORTABLE DIRECT-READING REVERBERATION METER.—H. J. Sabine. (*Electronics*, March 1937, Vol. 10, No. 3, pp. 30–31 and 35.)

2230. REVERBERATION AND ABSORPTION OF SOUND [Lecture, including Recent German Research].—E. Meyer. (*Journ. Acoust. Soc. Am.*, Jan. 1937, Vol. 8, No. 3, pp. 155–161.)

2231. THE THEORY OF SOUND TRANSMISSION THROUGH POROUS AND NON-POROUS MATERIALS.—M. Rettinger. (*Journ. Acoust. Soc. Am.*, Jan. 1937, Vol. 8, No. 3, pp. 172–175.)

2232. SOUND ABSORPTION IN SOLID BODIES [treated as Result of Collisions between Sound Quanta and Debye Heat Quanta: Linear Frequency Dependence of Absorption Coefficients].—Landau & Rumer. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 11, 1937, pp. 18–25: in German.)

2233. A MODIFIED TUBE METHOD FOR THE MEASUREMENT OF SOUND ABSORPTION [of Small Samples].—K. C. Morrical. (*Journ. Acoust. Soc. Am.*, Jan. 1937, Vol. 8, No. 3, pp. 162–171.) With results on some commercial materials.

2234. ON THE VIBRATIONS OF PIANO STRINGS.—O. Vierling. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 18, 1937, pp. 103–105.)

2235. TRANSIENT PROCESSES IN STRINGED INSTRUMENTS.—H. Backhaus (with E. Weise). (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 18, 1937, pp. 98–103.) Further development of the work dealt with in 1932 Abstracts, p. 289.

2236. THEORY OF THE HASKELL ORGAN PIPE, *and* THE "STRIKE NOTE" OF BELLS.—A. T. Jones. (*Journ. Acoust. Soc. Am.*, Jan. 1937, Vol. 8, No. 3, pp. 196–198: pp. 199–203.)

2237. DEVELOPMENTS IN AIRCRAFT SOUND CONTROL [Noise Reduction].—H. H. Bruderlin. (*Journ. Acoust. Soc. Am.*, Jan. 1937, Vol. 8, No. 3, pp. 181–184.)

2238. THE DIRECTIVE RECEPTION OF NOISES.—E. Paolini. (*Alta Frequenza*, March/April 1937, Vol. 6, No. 3/4, pp. 165–208.)
Simple binaural reception: linear system of detectors: circular and spherical systems: system arranged irregularly in space. Theory: practical constructional notes.

2239. ELECTRICAL STIMULATION OF THE COCHLEA [involves Same Peripheral Mechanism as Stimulation by Air-Borne Sounds].—E. Bárány. (*Nature*, 10th April 1937, Vol. 139, p. 633.)

2240. ORIGIN OF THE COCHLEAR EFFECT [Indirect Experimental Support for Membrane Theory].—O. Gatty & A. F. Rawdon-Smith. (*Nature*, 17th April 1937, Vol. 139, p. 670.)

2241. THE RESPONSE OF THE MAMMALIAN COCHLEA TO PHASE-REVERSAL IN A CONTINUOUS MUSICAL TONE [must originate in Some Non-Resonant Structure: Objective Evidence of Phase-Change Beat].—C. S. Hallpike, H. Hartridge, & A. F. Rawdon-Smith. (*Proc. Phys. Soc.*, 1st March 1937, Vol. 49, Part 2, No. 271, pp. 190–193.)

2242. THE AUDIBLE EFFECT OF A SUDDEN CHANGE OF PHASE IN THE CURRENT SUPPLIED TO A TELEPHONE RECEIVER [demonstrated by Electrical Experiment].—L. Hartshorn. (*Proc. Phys. Soc.*, 1st March 1937, Vol. 49, Part 2, No. 271, pp. 194–197: demonstration circuit.)

2243. AEF PROPOSED STANDARD TERMINOLOGY IN ACOUSTICS.—(*E.T.Z.*, 11th March 1937, Vol. 58, No. 10, p. 285.)

2244. A NEW ELECTRICAL SPEECH APPARATUS FOR THE IMITATION OF HUMAN VOWELS.—K. W. Wagner. (*Elektrot. u. Masch:bau*, 28th Feb. 1937, Vol. 55, No. 9, pp. 105–106.)

2245. ON HEARING BY ELECTRICAL STIMULATION [Experimental Results].—S. S. Stevens. (*Journ. Acoust. Soc. Am.*, Jan. 1937, Vol. 8, No. 3, pp. 191–195.)

2246. THE PRESSURES AND TENSIONS OF RADIATION.—L. Brillouin. (*Revue d'Acoustique*, Fasc. 3/4, Vol. 5, 1936, pp. 99–111.)

2247. ON THE PROBLEM OF THE QUANTITATIVE ESTIMATION OF THE FORCE OF A SOUND.—S. N. Rschevkin & A. V. Rabinovitch. (*Revue d'Acoustique*, Fasc. 5/6, Vol. 5, 1936, pp. 183–200.)

2248. EFFECT OF TURBULENCE ON THE PROPAGATION OF SOUND [illustrated by Studies of Attenuation of Fog-Horn Sound at Sea Surface].—H. Dahl & O. Devik. (*Nature*, 27th March 1937, Vol. 139, pp. 550–551.)

2249. CHARACTERISTICS OF SHOCK-WAVE PROPAGATION NEAR AN EXPLOSIVE SOURCE ["Free" Sound Field with Velocities Several Times the Normal Velocity].—L. Thompson & N. Riffolt. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, p. 377: abstract only.)

2250. THE MECHANICAL ACTION OF THERMAL ELASTIC WAVES IN LIQUIDS [Theory giving Calculation of Pressure Difference between Two Isothermal Planes].—F. Perrin & R. Lucas. (*Comptes Rendus*, 22nd March 1937, Vol. 204, No. 12, pp. 960–961.) Theory applying to experiments referred to in 1452 of April.

2251. Acoustic Spectrum of [Organic] Liquids [with Fabry-Perot Patterns of Incident and Scattered Radiation: Some Liquids have Organised Sound Waves as Part of Thermal Agitation].—C. V. Raman & B. V. R. Rao. (*Nature*, 3rd April 1937, Vol. 139, pp. 584–585.)

2252. Floating Particles in an Acoustic Field [Theory and Photographs of Behaviour of Aerosols and Acoustic Coagulation].—O. Brandt, H. Freund, & E. Hiedemann. (*Zeitschr. f. Physik*, No. 7/8, Vol. 104, 1937, pp. 511–533.)

2253. The Smoke Method of Measuring Supersonic Velocities [Error Sources eliminated: Measurement of Supersonic Velocities in Air, Oxygen, Nitrogen: No Evidence of Dispersion].—R. C. Parker. (*Proc. Phys. Soc.*, 1st March 1937, Vol. 49, Part 2, No. 271, pp. 95–104.) For the method *see* Pearson, 2708 of 1935.

2254. "Dark Bands in the Spectra of Acoustical and Optical Double Gratings": Theoretical Extension and Additional Researches to a Paper by Cermak & Schoeneck.—R. Bär: Cermak & Schoeneck. (*Helvet Phys. Acta.*, Fasc. 2, Vol. 10, 1937, pp. 130–138: in German.) *See* 3474 of 1936.

2255. Absorption and Diffusion of Supersonic Waves, and [New Deductions on] the Structure of Liquids.—R. Lucas. (*Journ. de Phys. et le Radium*, Feb. 1937, Vol. 8, No. 2, pp. 41–48.)

2256. Singing Flames [Special Form of Sensitive Flame, "singing" without any Associated Resonator: Possible Applications of These and of Ordinary Sensitive Flames].—Z. Carrière. (*Revue d'Acoustique*, Fasc. 3/4, Vol. 5, pp. 112–138.)

PHOTOTELEGRAPHY AND TELEVISION

2257. The Large Picture Problem in Television [VDE Lecture on Cinema Television].—A. Karolus. (*Funktech. Monatshefte*, March 1937, No. 3, Supp. pp. 21–25.)

Beginning with a table giving the illumination, in lumens, and the number of lines necessary for various picture sizes (from the home ciné to specially large cinemas), for two grades of brightness (25 and 100 lux), the writer goes on to survey the possibilities of the four main schemes: 1—Intermediate film, including various suggested methods of overcoming the high cost of the photographic film process, such as Selényi's electrographic method (*see*, for example, 669 of February) which however he considers would have to use a multi-channel system, and should therefore really go into Class 2. The Scophony supersonic-wave method is also discussed here, together with Alexanderson's method of "electrical focusing." 2—Multi-channel methods, using Weiller mirror-wheels, etc. 3—"Cell raster" methods, which are among the oldest but which, the writer concludes, provide in their improved technique (including dry-plate rectifiers for each lamp, grid-controlled luminescent lamps with hot cathodes, cathode-ray switching devices, etc.) the most hopeful solution. 4—The high-power cathode-ray tube, which he considers to be hopeless, especially now that researches in America have shown that the replacement of fluorescent materials by thermally luminescent substances is unsatisfactory, owing either to time lag or (if this is cured) to rapid deterioration.

2258. Large-Screen Television: Scophony Prospects: German Technical Views.—(*Television*, Feb. 1937, Vol. 10, No. 108, p. 68.)

2259. The Future of Television: Why a New Technique of Presentation must be Developed.—R. W. Hallows. (*Wireless World*, 16th April 1937, Vol. 40, pp. 370–371.)

2260. Television: the B.B.C.'s Questionnaire to Viewers.—(*Television*, Feb. 1937, Vol. 10, No. 108, p. 78.)

2261. Television at the Berlin Radio Exhibition, 1936.—Traub: Taylor. (*Journ. Television Soc.*, Dec. 1936, Vol. 2, Part 6, pp. 181–187: pp. 188–191.) The second paper includes a comparative table of results given by the various receivers.

2262. Modern Developments in Television: Part I—Transmission Systems.—S. T. Stevens. (*P.O. Elec. Eng. Journ.*, April 1937, Vol. 30, Part 1, pp. 37–45.)

2263. The Television Transmitter in the Philips Laboratory [for Sequential or Interlaced Scanning].—J. van der Mark. (*Philips Transmitting News*, March 1937, Vol. 4, No. 1, pp. 18–26.)

2264. Philco shows 441-Line Television [with 4.5 Mc/s Side-Bands (using Special Method of Modulation, not revealed): Comparison of Results with 345-Line Images].—Philco Company. (*Electronics*, March 1937, Vol. 10, No. 3, pp. 8–9.)

2265. The Mihaly-Traub System Up-to-Date.—(*Television*, Nov. 1936, Vol. 9, No. 105, pp. 635–636 and 668.)

2266. The Baird "Televisor" Receiving Set [Demonstration and Discussion].—T. M. C. Lance. (*Journ. Television Soc.*, Dec. 1936, Vol. 2, Part 6, pp. 192–197.)

2267. "Television's" Guaranteed Cathode-Ray Receiver [for the Amateur Constructor].—(*Television*, Nos. 104–109, namely:—Oct., Nov., Dec. 1936, Vol. 9: Jan. 1937, Vol. 10: Operating Notes on Time Bases, Feb. 1937: Reduction in Cost for Short Ranges, March 1937.)

2268. Television without Mains Supplies: a Scheme for "Portable" Television by the Loewe Company [with Frame Time-Base Voltage from Rotating Commutator Disc, Line Time-Base Voltage from Rotating Condenser Plate].—L. S. Kaysie. (*Television*, Oct. 1936, Vol. 9, No. 104, pp. 571–572.)

2269. THE TELEVISION RECEIVER: VII—THE SIGNAL/NOISE RATIO AND SUPERHETERODYNE INTERFERENCE PROBLEMS.—W. T. Cocking. (*Wireless World*, 16th April 1937, Vol. 40, pp. 376–378.)

2270. CONTRAST OR PICTURE BRIGHTNESS? SOME NOTES ON SECURING THE BEST RESULTS.—R. L. Ashmore. (*Television*, March 1937, Vol. 10, No. 109, pp. 145–146.)

2271. THE PHOTOGRAPHING OF TELEVISION IMAGES [Notes from the Writer's Practical Experience, with Specimen Results].—M. von Ardenne. (*Funktech. Monatshefte*, March 1937, No. 3, Supp. pp. 25–27.)

2272. MAGNETIC FOCUSING, *and* ELECTROSTATIC FOCUSING.—H. Wood: G. Parr. (*Wireless World*, 2nd April 1937, Vol. 40, pp. 320–322: pp. 328–329.)

2273. FORMATION OF ELECTRON LENSES BY MEANS OF RESISTANCE SPIRALS.—von Ardenne. (*Television*, Dec. 1936, Vol. 9, No. 106, p. 696.) For an abstract of the original German paper *see* 322 of January.

2274. THE ION LINE ON CATHODE-RAY TUBE SCREENS.—von Ardenne. (*Television*, Nov. 1936, Vol. 9, No. 105, pp. 626 and 627.) For abstract of the original German article *see* 292 of 1936.

2275. FLUORESCENT SCREENS.—(*Wireless World*, 2nd April 1937, Vol. 40, pp. 336–337.)

2276. THE ABSORPTION OF IONIC CRYSTALS IN THE ULTRA-VIOLET [Measurements of Bands of Films of Alkali Halides on Lithium Fluoride: Alkaline Earths show Sharp Absorption Edges].—E. G. Schneider & H. M. O'Bryan. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, pp. 293–298.)

2277. DEPENDENCE OF LUMINESCENCE ON PHYSICAL STRUCTURE IN ZINC BORATE COMPOUNDS [Change from Vitreous to Granular State increases Luminescence: Addition of Activator results in Condensation of Emission Bands and Increase in Their Wavelengths: Bearing on "Solid Solution" Idea].—D. H. Kabakjian. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, pp. 365–368.)

2278. APPARATUS FOR THE MEASUREMENT OF AFTERGLOW AND THE COMPARISON OF THE MAXIMUM BRIGHTNESS OF PHOSPHORS, ESPECIALLY FOR TELEVISION PURPOSES.—W. Pragst. (*Funktech. Monatshefte*, Feb. 1937, No. 2, Supp. pp. 19–20.)

The phosphor is carried on a fixed glass plate P between two discs driven by a common motor but adjustable as to the phase angle. Disc I (detached in Fig. 2 to reveal the phosphor plate P) has one radial slit, some 12 mm wide, and intervenes between P and the condenser lens C (and its ultra-violet filter U) of the arc lamp B: see also Figs. 2 and 3. Disc II, on the far side of the phosphor plate, carries a detachable grating R (seen separated from its disc in Fig. 3) consisting of six metal strips, parallel to the edge of the disc, separated by spaces. On the far side of disc II is a fixed screen III with an opening $\ddot{O}$ on the axis of the optical system: this is best seen in Fig. 4. It is through this opening that the processes are watched.

The four middle strips of the grating R on disc II are coated with a phosphor (which may be the same as that under observation, on P); the other two strips are left plain (Fig. 3). As this grating rotates on its carrier disc II it passes a "Kinox" lamp K (Fig. 4) whose brightness can be adjusted so that the coated bars of the grating can, in their passage, be excited to a desired degree of fluorescence. This glow, as it passes the observation opening $\ddot{O}$, can be made to match the glow (seen through the spaces of the grating) due to the phosphor plate P. By shifting the phase of disc II relative to disc I by an angle representing a definite afterglow time, it can be arranged that the direct, maximum fluorescence of P no longer reaches the observation opening through the spaces of the rotating grating: its brightness is, however, still represented by the glow of the four grating bars. All that is visible from P is the afterglow, showing as a more or less dark background to the bright grating bars. If the discs are rotated at 10 r.p.s., decay times of from 1/10th to 1/100th sec. can be represented by adjusting the phase between the discs, and this decay time can be increased until the dark background appears as black as the two completely black untreated bars of the 6-bar grating. The decay time can then be read off the phase-changing scale on disc I, calibrated in fractions of a second.

If it is desired to plot the decay curve, the grating is removed from disc II and the afterglow light reaching the observation opening is measured photometrically for various phase angles between discs I and II. To compare the maximum brightness of two different phosphors, the two discs are set "in phase" and the grating glow is first matched against plate P and then against plate P' carrying the second phosphor. In all cases the preliminary step is to adjust the brightness of the arc lamp B so that the fluorescence excited by its ultra-violet radiation corresponds to the fluorescence which would be excited if the material were used in a cathode-ray tube.

2279. HARD-VALVE TIME BASES [for Cathode-Ray Tubes].—Puckle. (*Wireless World*, 2nd April 1937, Vol. 40, pp. 316–318.)

2280. TELEVISION INTERMEDIATE REPEATERS [in Use on Television Cable Link between Berlin and Leipzig].—V. Gandtner. (*T.F.T.*, Feb. 1937, Vol. 26, No. 2, pp. 37–40.)

2281. TELEVISION INTERFERENCE TEST SET [for G.P.O.].—(*Wireless World*, 23rd April 1937, Vol. 40, pp. 398–399.)

2282. SOME TELEVISION AERIAL EXPERIMENTS: AN ACCOUNT OF PRACTICAL RECEPTION TESTS.—(*Television*, Feb. 1937, Vol. 10, No. 108, pp. 81–82.)

2283. LENSES MOULDED FROM PLASTICS ["Perspex," etc.].—(*Television*, March 1937, Vol. 10, No. 109, p. 139.)

2284. REVOLVING MIRRORS—A THEOREM [of Use in Study of Distortions in Ray Path].—C. Dalton. (*Television*, March 1937, Vol. 10, No. 109, p. 140.)

2285. A METHOD OF INVESTIGATING THE TRANSIENT CHARACTERISTICS OF ELECTRICAL CIRCUITS. —Morse. (*See* 2084.)

2286. THE DESIGN OF VISION-FREQUENCY AMPLIFIERS [with High and Low Frequency Correction : Theory and Experimental Confirmation].—P. Nagy. (*Television*, March 1937, Vol. 10, No. 109, pp. 160–161 and 162 : to be contd.)

2287. SOME DATA ON THE QUESTION OF THE RELATION BETWEEN SECONDARY ELECTRON EMISSION AND PHOTOSENSITIVITY.— A. Dobrolyubski. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 11, 1937, pp. 118–121 : in German.)

By tests on the secondary emission from layers of Cs–Cs_2O on silver, copper, and nickel, and by the analysis of their spectral characteristics, the writer has shown that the value of the coefficient of secondary emission (from electron bombardment) is closely related to the integral photosensitivity in the ultra-violet region but not in the visible or infra-red regions. The problem of the origin of secondary emission seems therefore bound up with that of the origin of the integral sensitivity in the ultra-violet region. Thus the silver, copper, and nickel variations of the composite cathodes show marked differences in photosensitivity in the visible and infra-red regions, and practically equal photosensitivities in the ultra-violet region (Kluge, 3151 of 1935) ; the coefficient of secondary emission is approximately the same for all of them. According to the writer's measurements, this coefficient is 2–3 at 150 volts (and " 3–4.1 at 150 volts "—there is an ambiguity here) : " the higher values usually obtained with the caesium-oxygen layers on silver are a result rather of the better technological process . . . than of the influence of the under layer itself " (the colour changes of the silver oxide facilitate the correct preparation of the composite layer).

This lack of dependence of the secondary emission on the nature of the under layer may be explained in two ways. The first interpretation, which is supported by Rudberg's work on the inelastic reflection of electrons (3792 of 1936) and by the known fact that the photosensitivity and secondary-emission sensitivity of the prepared layers are both increased by treatment with oxygen and subsequent heating, is that the secondary emission proceeds from the Cs_2O–Cs layer and that the rôle of the under layer is limited to the storing-up of oxygen and its release on heating, to form the Cs_2O. On the other hand there are arguments in favour of a deeper penetration and of a participation in the emission process by particles of the metal of the under layer ; a final decision could be reached by experiments on secondary emission from Cs_2O–Cs layers on an insulating under layer.

When a Cs–Cs_2O–Ag cathode is fatigued, the chief loss of photosensitivity is in the visible and infra-red regions. The only slight change in the integral sensitivity in the ultra-violet region corresponds with the only slight change in the secondary emission. Finally, another fact of interest is that in various Cs–Cs_2O–Ag cathodes which show marked differences in integral photosensitivity, the falling off is chiefly in the infra-red and (to a smaller extent) the visible region, while the differences in secondary emission are far smaller : thus one cathode, of photosensitivity 20 times smaller than that of another, had a secondary-emission coefficient of 2.5 to the other's 3.5.

2288. SOFT X-RAY AND PHOTOELECTRONS FROM NICKEL AT DIFFERENT TEMPERATURES [with Discussion of Abrupt Change of Secondary Emission from Nickel at Curie Point].—S. R. Rao. (*Proc. Roy. Soc.*, Series A, 15th March 1937, Vol. 159, No. 897, pp. 283–294.)

2289. THE PHOTOELECTRIC WORK FUNCTIONS OF THE 211 AND 310 PLANES OF TUNGSTEN [Values determined using Fowler's Method]. —C. E. Mendenhall & C. F. DeVoe. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, pp. 346–349.)

2290. THE SHENSTONE EFFECT IN BISMUTH [Variations in Photoelectric Sensitivity of Bismuth when Electric Currents pass through It are due to Changes in Gas occluded by Metal].—A. H. Weber & C. B. Bazzoni. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, p. 378 : abstract only.)

2291. NOTE ON QUANTUM ABSORPTION PROBABILITY IN THE CASE OF THE PHOTOELECTRIC EFFECT [Probability of Absorption of Quantum is proportional to Square of Electron's Normal Velocity Component].—A. T. Waterman. (*Phys. Review*, 1st March, 1937, Series 2, Vol. 51, No. 5, p. 378 : abstract only.)

2292. PHOTOELECTRIC GEIGER-MÜLLER COUNTERS FOR VISIBLE AND ULTRA-VIOLET LIGHT [New Developments in Technique].—G. L. Locher. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, p. 386 : abstract only.)

2293. INFLUENCE OF PRE-ILLUMINATION AND OF TEMPERATURE ON THE ABSORPTION OF LIGHT IN Cu_2O.—S. I. Goloub & G. A. Koulev. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 11, 1937, pp. 168–181 : in French.)

2294. ON THE QUESTION OF THE PROPERTIES OF THE BARRIER LAYER IN " VALVE-LAYER " PHOTOCELLS.—W. P. Jouse [Jusé]. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 11, 1937, pp. 122–127 : in German.)

In his paper on synthetic barrier-layer rectifiers (2048 of 1935) the writer mentioned that his attempts to make photocells on the same principle were unsuccessful so long as his artificial barrier-layer, spread on the semiconducting Cu_2O, was composed of a substance such as SiO_2 or B_2O_3 which had no internal photoeffect ; but that a good " valve-layer " photocell could be obtained if a substance such as Tl_2S, with a large internal photoeffect, was employed as the artificial barrier layer. Further researches have brought to light a marked dependence of the phenomenon on the thickness of the Tl_2S layer, the spectral sensitivity curves of cells with thicknesses ranging from 10^{-3} to 10^{-6} cm having different shapes in the region of the shorter waves. Thus curve II, of a cell with a thin Tl_2S layer, has a " hump " corre-

sponding very closely to the maximum of the usual frontal Cu_2O photocell (curve I), whereas a thicker Tl_2S layer gives no such " hump " (dotted portion of curve III), though both curves coincide towards the longer wavelengths and rise in a way which suggests the existence of a second maximum, presumably corresponding to the photoeffect of the Tl_2S.

If, however, special precautions (cooling by liquid air, etc.) are taken during the process of deposition of Tl_2S on the Cu_2O, to avoid any possible accidental " sensitisation " of the Cu_2O surface by electron or ion bombardment, both thin and thick Tl_2S layers give curve III, the first " hump " disappearing. In view of the writer's results it is thought that the (very small) photocurrents obtained by van Geel (3988 of 1935), from selenium cells with artificial barrier layers of substances presenting no internal photoeffect, must be attributed to such accidental sensitisation of the semiconducting surface.

Finally, it is mentioned that these synthetic photocells in general give much smaller values of photoeffect than ordinary cells under the same conditions : the structure of the barrier layer must play an important part.

MEASUREMENTS AND STANDARDS

2295. " The Measurement of Currents at Very High Frequencies."—H. Schwarz. (*Electronics*, Feb. 1937, Vol. 10, No. 2, p. 56.) Notice of a U.S. Bureau of Census booklet including a translation of Schwarz's paper, dealt with at length in 1932 Abstracts, pp. 471–472.

2296. Micro-Waves : Part VI—Measurement. —Carrara. (*Alta Frequenza*, March/April 1937, Vol. 6, No. 3/4, pp. 236–242.) For previous parts *see* 2058, above.

2297. Measurement of the Ultra-High-Frequency Absorption [in Liquid Dielectrics] by a Thermal Method.—Zouckermann & Freymann. (*Journ. de Phys. et le Radium*, March 1937, Vol. 8, No. 3, pp. 103–110.) For a *Comptes Rendus* Note *see* 3527 of 1936.

2298. On the Problem of the Measurement of Power from Magnetron Generators on Decimetre Waves.—S. J. Braude & A. A. Slutzkin. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 11, 1937, pp. 69–77 : in German.)

The photocell (anode-heating) method is unsatisfactory because in the generating condition the anode is not heated uniformly : Pfetscher & Puhlmann's cooling-water method (2950 of 1936) seems more reliable but can only be applied to certain designs of magnetron : the method of Leljakov and colleagues, with " intermittent oscillations," using a ballast resistance in the anode circuit (924 of March), is rather difficult to work out : absorption by incandescent lamps or thermo-elements in inductively coupled resonance circuits, as used by various workers, can be applied successfully only with small powers, since with larger powers the filaments would have to be so long that the circuit would not be applicable to decimetre wavelengths.

The task is greatly simplified if the energy is dissipated by a *radiating* resistance such as a suitably coupled tuned aerial, but unfortunately the formulae which fairly simply give the radiation resistance on longer waves are not applicable to the very short wavelengths. This is probably due to the fact that the sinusoidal current distribution is upset, for very short aerials, by the capacity effect of the ends and by reflection from near-by objects. Thus Sonoda found that the measured radiation resistance of half-wave aerials on 20 cm waves could be as much as 30% more than the theoretical value (1931 Abstracts, p. 97). Specially large discrepancies would be expected with a magnetron, since large masses of metal (electromagnets) would be near the aerial. In making power measurements with the help of aerials, the radiation resistance of the aerial must, therefore, be previously determined in conditions corresponding to the working conditions of the generator.

Such measurements of radiation resistance, on half-wave and one-and-a-half-wave aerials, are described, the method being the plotting of resonance curves, with and without an additional resistance in the aerial, by means of a thermoelement at the middle of the aerial : a second thermoelement, in the sliding bridge of the magnetron circuit itself, was used to keep constant the amount of energy in that circuit. The spacing between magnetron circuit and aerial was kept fixed at 2 cm. A holder, situated in the aerial near its centre, enabled the additional resistance to be introduced or to be replaced by a short copper rod. This resistance (whose ohmic value must greatly exceed its inductive value) was formed of a 10–15 mm length of selected lead pencil, of ohmic resistance 50–100 ohms. The resonance curves were taken by varying the length of the aerial. The radiation resistance of a particular aerial came out at 71 ohms (wavelength 116 cm), close to the calculated value. As a check, the damping-factor method (using Sonoda's formula involving the wavelengths at which the current is 0.707 times the resonance current) was tried : this gave a value of 73 ohms, higher than the calculated value.

Returning to the first method, it was found that on wavelengths shorter than the 116 cm the radiation resistances measured were greater than the calculated values (Fig. 3). This was due partly to increasing capacity effects of the aerial ends, but partly to an artificial effect arising from the fact that the shorter the magnetron-circuit wavelength the nearer was the sliding bridge (and consequently the aerial coupled to it) to the electromagnet poles, which were liable to alter the current distribution and hence the radiation resistance.

2299. Alternating Current Power Measurements by means of Rectifiers.—L. V. Voroshilov. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1937, pp. 29–40.)

Experimental investigation to check the theoretical considerations presented in a previous paper (2357 of 1935). Methods are indicated for designing the wattmeter, and a description is given of the models used. Experiments were conducted mainly at a frequency of 50 c/s (in a few experiments 300 and 400 c/s were used) but it is stated that

no adverse effects should become apparent until frequencies of the order of 5000 c/s are reached. The accuracy and sensitivity of the various models used, together with their electrical characteristics, are shown in a number of tables. It appears that this type of wattmeter is quite suitable for measuring, at the frequencies specified, powers ranging from a fraction of a watt to several hundred watts and higher.

2300. A Suggested Method of Power Measurement in Gaseous Discharges [Defects of Electrodynamic Wattmeter Method avoided by Interposition of Valve Voltmeter between Voltage Winding and Discharge Tube].—H. Schmellenmeier. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 18, 1937, pp. 35–37.)

2301. Discussion on "The Vectorial Representation of Power."—Iliovici. (*Bull. Soc. franç. des Élec.*, March 1937, Vol. 7, No. 75, pp. 332–361.)

2302. A New Method of Measuring the Ferromagnetic Properties of Metals in the Region of Very High Frequencies (Wire Bridge Method).—G. Potapenko & R. Sänger. (*Zeitschr. f. Physik*, No. 11/12, Vol. 104, 1937, pp. 779–803.)

This method is suitable for frequencies 10^8–10^{10} c/s and requires only very small samples of the metal under investigation. It is essentially a Lecher system of parallel copper wires, with a fixed wire bridge of the required metal at one end and a movable, completely reflecting bridge at the other. The resonance curve (variation of energy with bridge distance) of the standing waves in the system has maxima whose height depends in part on the ohmic losses and thus on the magnetic permeability, which can therefore be measured by this method. The theory is worked out and the advantages and sources of error are discussed. A critical discussion of other methods of permeability measurements at high frequencies precedes the description of the new method.

2303. A High-Frequency Resistance Bridge [for Frequencies 20–2000 kc/s: for Rapid and Accurate Measurements on Iron-Dust-Cored Coils, or Direct Comparison of Condensers: including a Variable H.F. Resistance (Thin Platinum Coating on Glass Rod, with Piston-Controlled Mercury Column as Moving Contact].—C. Austin & A. L. Oliver. (*Marconi Review*, Nov./Dec. 1936, No. 63, pp. 22–26.)

2304. The Capacitance of a Parallel-Plate Capacitor by the Schwartz-Christoffel Transformation.—H. B. Palmer. (*Elec. Engineering*, March 1937, Vol. 56, No. 3, pp. 363–366.)

2305. On the Calculation of the Coefficient of Mutual Induction between a Circumference and a Circuit of Any Shape Whatever.—R. Sartori. (*L'Elettrotec.*, No. 5, Vol. 24, 1937, pp. 135–138.)

2306. The Impedance of Tubular Conductors: Approximate Formulae for High Frequencies [neglecting Dielectric Losses: Treatment using Hankel Functions].—G. Maione. (*L'Elettrotec.*, No. 22, Vol. 23, 1936, pp. 691–693.)

The results show the limits to the desirable use of tubular conductors for high frequencies: if $x = 2(r_2 - r_1)\sqrt{f\mu/\rho}$ (usual notation) then so long as x remains less than 0.33 the ratio of the equivalent resistance to the d.c. resistance is near to unity, being practically dependent only on the value of r_m/r_2; the skin effect is negligible. For larger values of x the skin effect is no longer negligible, and for values greater than unity the tubular conductor can be regarded as equivalent in resistance to a conductor of thickness equal to the penetration depth $\Delta_e = 1/2\pi \cdot \sqrt{\rho/f\mu} \cdot (1 + \frac{1}{8}\Delta/r_m)$.

2307. Measurements of the High-Frequency Resistance of Single-Layer Solenoids [by Moullin's Method: for Testing the Accuracy of Butterworth's Formulae].—W. Jackson. (*Journ. I.E.E.*, April 1937, Vol. 80, No. 484, pp. 440–445.)

One formula was found to be correct to within about 4% for 30- and 50-turn coils over the whole range of 200–2025 kc/s: for 10-turn coils a second formula gave reasonably good agreement (underestimates by about 5–10%). For Moullin's method *see* 1932 Abstracts, pp. 593–594.

2308. Some Series Formulas for Mutual Inductance of Solenoids.—H. B. Dwight & F. W. Grover. (*Elec. Engineering*, March 1937, Vol. 56, No. 3, pp. 347–353.)

2309. A Method of Measuring High Resistances [10–100 × 10^6 Megohms (*e.g.* "Figure of Merit" of Very Small Condensers): Convenient Electrostatic Method at 100–200 Volts].—H. Gönningen. (*E.T.Z.*, 25th March 1937, Vol. 58, No. 12, pp. 316–318.)

Also suitable for measurement of the insulation resistance of highly insulating oils and greases. The writer's instrument for measuring the "figure of merit" (megohms × microfarads) of small condensers has already been successfully in service for some years (*see* 548 of 1935) and it is this, in a modified circuit, which can be used for the measurement of resistances of the order of 10–100 "teraohms" (one "teraohm" = 10^{12} ohms). The basis of the method is Kohlrausch's formula for the spontaneous discharge of a condenser, $R = t/\{C(\log V_1 - \log V_2)\}$ where R is in ohms, t in seconds, C in farads, and the initial and final voltages in volts. This equation yields a family of curves from which the figure of merit can be derived: the voltage measuring instrument must take no appreciable current, so that only one of electrostatic type is suitable, and that actually used is Palm's design (1934 Abstracts, p. 334), with amber insulation. The special oil container is also insulated with amber. The apparatus is portable, and measurements can be made in about a tenth of the time taken by ordinary static methods. The figure of merit of condensers of unknown capacity can be read directly off the table.

2310. A NEW VALVE PHASEMETER.—G. Opitz. (*Hochf:tech. u. Elek:akus.*, Feb. 1937, Vol. 49, No. 2, pp. 52–56.)

This valve phasemeter is stated to be free from the calibration difficulties hitherto attaching to these instruments, and to give a high degree of accuracy in measurement. The circuit is shown in principle in Fig. 1; four valves are arranged symmetrically. The two outside ones work in a rectifying circuit (working point Fig. 2a) with galvanic coupling to the two inner stages (working point Fig. 2b). The anode current in the inner valves is shown in Fig. 3; for phase measurement, this must be made as rectangular as possible. This can be done by choosing large values of the input amplitude U_0. The relation (eqns. 4.2, 4.3) between the permissible error in the anode current and the minimum value of U_0 is found theoretically by using a parabolic approximation to the dynamic valve characteristic (Fig. 4). The vector sum of the anode currents of the inner valves is the current through the indicator (galvanometer or thermo-element) and measures the phase displacement of the input voltages; this is determined by formulae 5, 5.1, which differ only in sign. Fig. 7 shows the circuit of an actual phasemeter. The measurement of inductances (circuits Fig. 8) and capacities (circuits Fig. 9) is also described, with formulae (eqns. 7 and 9 respectively).

2311. DIELECTRIC LOSS MEASUREMENTS PARALLEL TO LAMINATIONS [Test Method for Measurement of Power Factor, Dielectric Constant, and Dielectric Loss Factor of Laminated Insulating Materials: Results compared with Those perpendicular to Laminations, for Unconditioned and Conditioned Phenolic Materials].—G. A. Albert. (*Journ. of Applied Phys.* [formerly *Physics*], March 1937, Vol. 8, No. 3, pp. 218–226.)

2312. A NOTE ON HIGH-FREQUENCY DIELECTRIC LOSS MEASUREMENT USING A STANDARD CONDENSER WITH SOME LOSSES.—Nakazi. (*Journ. I.E.E. Japan*, Oct. 1936, Vol. 56 [No. 10], No. 579, p. 1127: Japanese only.)

2313. THE DIELECTRIC POLARISATION OF *n*-LONG CHAIN KETONES NEAR THEIR MELTING POINTS [measured by Lecher-Wire Method at Wavelength 8.9 m].—A. Müller. (*Proc. Roy. Soc.*, Series A, 15th Jan. 1937, Vol. 158, No. 894, pp. 403–414.)

2314. THE MEASUREMENT OF RAPID VARIATIONS OF FREQUENCY [Commercial, Audio-, or Radio-]: FREQUENCY-MODULATION MEASUREMENT.—V. Babits. (*Elektrot. u. Masch:bau*, 28th Feb. 1937, Vol. 55, No. 9, pp. 102–103.)

A condenser C (Fig. 3) is charged from a battery B_1 and discharged through a resistance R, the charging taking place during a half-period of the frequency under observation and the discharge during the other half-period: this process is controlled by the valve E, in a Class B amplifier connection. The voltage changes at the end of the discharge process and beginning of the charging process are amplified by the amplifier V, whose first valve is so negatively biased (battery B_3) that all parts of the curve lying to the left of a (Fig. 2) are completely suppressed. The amplified voltages are applied to one pair of plates of a cathode-ray oscillograph, the other pair providing the horizontal time-base from the relaxation oscillator K. Since the condenser voltage at the end of the discharge process depends on the time given to that process (controlled by the second half-period of the frequency under observation), if the frequency is practically constant the envelope of the peaks is approximately a straight line.

The vertical displacement of the peaks can be calibrated by a constant known frequency. If sudden fluctuations occur, the envelope is no longer approximately a straight line; in this case photographic recording is impossible since the plate sensitivity is not high enough, and visual observations are necessary. It is pointed out that for aperiodic fluctuations of frequency the von Ardenne polar-coordinate oscillograph (1103 of March) is specially suitable.

2315. A LABORATORY FREQUENCY STANDARD [Crystal-Controlled Clock and Auxiliary Equipment allowing Measurement of Radio- and Audio-Frequencies to 1 Part in 10^8 or better].—Harnwell & Kuper. (*Review Scient. Instr.*, March 1937, Vol. 8, No. 3, pp. 83–86.) Standardised by signals from WWV.

2316. "SHORT SIDE" VIBRATION OF A RECTANGULAR OSCILLATING QUARTZ PLATE, AND THE TEMPERATURE COEFFICIENT OF ITS FREQUENCY, *and* QUARTZ PLATES OF ZERO TEMPERATURE COEFFICIENT, EASY TO CUT.—Koga & Shoyama: Yoda. (*Journ. I.E.E. Japan*, Oct. 1936, Vol. 56 [No. 10], No. 579, p. 1123: p. 1124: Japanese only.)

2317. DIMENSIONS OF A RECTANGULAR OSCILLATING QUARTZ PLATE AND THE TEMPERATURE COEFFICIENT OF ITS LOW FREQUENCY.—Yoda. (*Journ. I.E.E. Japan*, Dec. 1936, Vol. 56 [No. 12], No. 581, p. 1245: Japanese only.)

2318. THE BRUSH "TRANSFILTER" [Rochelle Salt Oscillator combined with Vibrating Steel Bar].—Lamb. (*See* 2136.)

2319. EXPERIMENTS ON PIEZOELECTRIC OSCILLATIONS WITH ROCHELLE SALT CRYSTALS.—R. Hiltscher. (*Zeitschr. f. Physik*, No. 9/10, Vol. 104, 1937, pp. 672–680.)

The theory of the piezoelectric effect for Rochelle salt crystals is worked out; it is found that a plate of Rochelle salt cannot be excited to produce transverse oscillations (in contrast to quartz). Experiments on longitudinal oscillations (circuit Fig. 3) and connected optical effects (analogous to those for quartz described by Giebe & Scheibe, *Zeitschr. f. Physik*, Vol. 33, 1925, p. 335) lead to the conclusion that Rochelle salt crystals would be very inefficient sources of supersonic waves. They would give only 1% of the power obtainable from quartz crystals.

2320. AN OVERLOADABLE VALVE VOLTMETER.—W. Kautter. (*E.N.T.*, Feb. 1937, Vol. 14, No. 2, pp. 45–48.)

This valve voltmeter can be used at both audio

and high frequencies; it is particularly recommended for use with a current recorder. The circuit is shown in Fig. 2; the chief point is the use of grid rectification by means of the diode-triode ABC 1. Details of the working are given; Fig. 3 shows the calibration curves for the various ranges. The input-impedance remains unchanged on switching from one range to another, since switching takes place on the d.c. side.

2321. A CALIBRATED SIGNAL GENERATOR FOR THE SIMPLIFICATION OF ATTENUATION MEASUREMENTS.—O. Limann. (*Hochf:tech. u. Elek:akus.*, Feb. 1937, Vol. 49, No. 2, pp. 57–64.)

This generator is intended for attenuation measurements by the detuning method (Fig. 2; attenuation factor eqn. 2); it has a tuning condenser with a logarithmic calibration curve and a fine adjustment calibrated in degrees of detuning (Fig. 8). It can be used for measurements on oscillating circuits which are built in to other apparatus. Detuning of the generator by changing its self-inductance (§ IIa) is described; a new coil with a "Sirufer" core was devised (Figs. 3, 4) but permitted measurements over only a limited range of frequency, so the capacity variation method (§ IIb) was chosen instead. The theory of the condenser with logarithmic calibration curve (Fig. 5) is given; the device used for fine adjustment is shown in Fig. 6 and its use described. The procedure of determining the voltage is given in § III; the output of the generator has an attenuating element by which the output voltage can be reduced in the ratio $1 : 1/\sqrt{2}$. Fig. 9 shows an ohmic potentiometer for doing this and for obtaining different voltage ranges. The calculation of the resistances composing it is given. The whole generator circuit, with its mains connection, a modulation valve, and the output potentiometer, is shown in Fig. 13; its calibration and test are described (§ V). In addition to its use as an attenuation meter for oscillating circuits and receivers (§ VIa), it can be used as a calibrating and test generator for broadcast receivers (§ VIb) and to measure the temperature coefficient of oscillating circuits (§ VIc) by measurement of small frequency changes.

2322. MEASUREMENT OF THE PLATE RESISTANCE OF HIGH-FREQUENCY CLASS B AND C AMPLIFIERS.—V. A. Babits. (*Comm. & Broad. Eng.*, Jan. 1937, Vol. 4, No. 1, p. 7.)

2323. A NOTE ON THE SENSITIVITY OF THE SCHERING BRIDGE NETWORK [Simplified Treatment for High-Voltage Bridge].—E. Bradshaw. (*Journ. Roy. Tech. Coll.*, Glasgow, Jan. 1937, Vol. 4, Part 1, pp. 144–146.)

2324. PRECISION MEASUREMENTS WITH AN A.C. POTENTIOMETER.—D. Connelly. (*Journ. Roy. Tech. Coll.*, Glasgow, Jan. 1937, Vol. 4, Part 1, pp. 159–172.)

2325. A CONDENSER-TRACKING TEST SET [with Automatic Visual and Aural Indication when Condenser differs by More than 0.01 $\mu\mu$F].—J. L. Roemisch. (*Electronics*, March 1937, Vol. 10, No. 3, pp. 12–15.)

2326. "ELEKTRISCHE MESSGERÄTE UND MESSEINRICHTUNGEN" [Book Review].—A. Palm. (*Electrician*, 2nd April 1937, Vol. 118, p. 458.)

SUBSIDIARY APPARATUS AND MATERIALS

2327. THE COURSE OF THE RAY IN ELECTRON-OPTICAL SYSTEMS [with Electrostatic Lenses].—Gans. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 18, 1937, pp. 41–48.)

Author's summary:—"The potential fields along the axis of a central-aperture stop and of an immersion lens are calculated. With the numerical values thus obtained the course of the ray and the positions of the focal and principal planes are calculated, the equation for the ray (eqn. 1) being numerically integrated by the Runge-Kutta process (Section 4). Other methods of calculation are provided by the replacement of the potential curve by part of a polygon (Section 5: *see* also dotted lines of Fig. 2) or by portions of a parabola (Section 7)."

The methods are illustrated by simple examples. All of them can be made to give accurate results, but the advantage of the "polygon" method is the rapidity with which approximate results can be obtained: it is an extension of the method of Davisson & Calbick (1933 Abstracts, p. 224). The "parabola" approximation is more accurate, and is used in a slightly different way by Recknagel (1954 of May). Incidentally, with reference to eqn. 16′ for the focal distance of an immersion lens, a footnote states that the formula given by Bedford (532 of 1935) is not correct.

2328. ELECTRON OPTICS [Survey].—Rodda. (*Journ. Television Soc.*, Dec. 1936, Vol. 2, Part 6, pp. 198–212.)

2329. RECENT PROGRESS IN THE DESIGN OF CATHODE-RAY OSCILLOGRAPHS [and the AEG High-Vacuum Portable Equipment with "Virtual Screen Enlargement"].—Pieplow. (*E.T.Z.*, 4th March 1937, Vol. 58, No. 9, pp. 242–244.)

The tube is provided with an additional, weakly positive stop *B* between the Wehnelt cylinder and the electrostatic lens: without this, the ray could not be strongly concentrated without loss of intensity. The "virtual enlargement" of the 10 cm-diameter screen, enabling any particular portion of the ordinary record to be examined on a larger scale, is attained by increasing the deflection and simultaneously shifting the zero line downwards, if necessary below the edge of the screen.

2330. NEW CATHODE-RAY TUBES FOR MEASURING PURPOSES [including Dual-Ray and Polar Coordinate Types: Nomogram for Choice of Tube for Given Recording Speed: etc.].—von Ardenne. (*Funktech. Monatshefte*, Dec. 1936, No. 12, pp. 453–456.)

2331. THE HOT-CATHODE CATHODE-RAY OSCILLOGRAPH [and Associated Equipment] OF THE HIGH-VOLTAGE TESTING LABORATORY, COSSONAY CABLE WORKS.—Foretay. (*Bull. Assoc. suisse des Élec.*, No. 6, Vol. 28, 1937, pp. 121–126: in French.)

2332. "Die praktische Verwendung des Elektronenstrahloszillographen" [Book Review].—Klein. (*Funktech. Monatshefte*, March 1937, No. 3, p. 102.)

2333. The Cathode-Ray Oscillograph [and Its Applications].—Hill. (*Wireless World*, 2nd April 1937, Vol. 40, pp. 326–327.)

2334. Other Papers on Cathode-Ray Tubes.—(*See* under "Phototelegraphy and Television.")

2335. Variation of the Secondary Emission of Some Metals with the Angle of Incidence of the Primary Cathode-Ray Beam.—Müller. (*See* 2180.)

2336. A New Time Base using a Gas-Filled Triode, Philips Type 4686.—Hughes. (*See* 2170.)

2337. The Recording of Transient Electrical Phenomena of Rapid Occurrence by the Cathode-Ray Oscillograph: Description of an Arrangement for the [Exponential] Time-Base Deflection [and Ray Locking].—Angelini. (*L'Elettrotec.*, No. 2, Vol. 24, 1937, pp. 34–46.)

With specimen oscillograms at frequencies up to 3.34 Mc/s. A long section deals with the analysis of the distorting effects of the parasitic capacities, and other disturbing elements, on the time-base deflection for high recording speeds. The writer's apparatus (Figs. 14–17: alternative circuits Figs. 3 and 4) is designed, on the basis of this analysis, to reduce these causes to a minimum: thus the connecting leads are kept extremely short, the adjustable spark-gaps being mounted on the end of the condenser, and the condenser-discharging resistance, of negligible inductance, lying axially inside the condenser, which itself is designed to have minimum armature resistance: its time constant is certainly not more than 10^{-9} sec.

2338. Recent Progress in the Methods of Atom- and Ion-Beam Investigation [including Canal Rays, the Cyclotron, Ion Optics, etc: General Survey].—Ritschl. (*Physik. Zeitschr.*, 1st March 1937, Vol. 38, No. 5, pp. 141–157.)

2339. Magnet Coils inside Vacuum Tubes, wound with Aluminium Wire insulated with Oxide "stopped" with Sodium Silicate.—Fernseh Company. (German Pat. 808 080, pub. 28.1.1937: *Rev. Gén. de l'Élec.*, 27th March 1937, Vol. 41, No. 13, p. 102D.)

2340. Apparatus for the Measurement of Afterglow, etc., of Fluorescent Materials.—Pragst. (*See* 2278.)

2341. Potential attained by Insulators when Bombarded by Electrons [Measurements for Glass, Willemite, Zinc Silicate, Calcium Tungstate: Potential and Secondary Emission: Results analogous to Those for Conductors].—Hagen & Bey. (*Zeitschr. f. Physik*, No. 9/10, Vol. 104, 1937, pp. 681–684.)

The method used is the direct measurement, by means of an electrometer string, of electrical field-strength in the space between the anode accelerating the electron beam and the insulated bombarded screen (arrangement Fig. 1). For work by an indirect method *see* Knoll, 3037 of 1936, and Strübig, 3491 of 1936.

2342. The First International Photoluminescence Congress in Warsaw, May 1936.—(*Acta Physica Polonica*, Vol. 5, 1936, 431 pp.) A large number of papers, many in German, a few in French, and one in English.

2343. AEF Proposed Standard Terminology of Pressures in Vacuum Technique.—(*E.T.Z.*, 11th March 1937, Vol. 58, No. 10, pp. 284–285.)

2344. Thermocouple Gauge for Vacuum Measurement [0.1 to 10^{-4} mm Hg].—Dunlap & Trump. (*Review Scient. Instr.*, Jan. 1937, Vol. 8, No. 1, pp. 37–38.)

2345. A High-Vacuum Cut-Off [Ring Seal with Steel "Hat" floating on Mercury and manipulated by Electro-Magnet].—Schmitt. (*Review Scient. Instr.*, Feb. 1937, Vol. 8, No. 2, pp. 68–69.)

2346. The Resolvometer [for testing the Resolving Power of Photographic Material for Various Purposes].—Burmistrov. (*Tech. Phys. of USSR*, No. 12, Vol. 3, 1936, pp. 1079–1089: in English.)

2347. Arc Extinction in a Thyratron [and the Bridge-Over Effect of the Positive Ion Sheath].—Watanabe & Aoyama. (*Journ. I.E.E. Japan*, Oct. 1936, Vol. 56 [No. 10], No. 579, pp. 1049–1056: English summary pp. 82–83.)

2348. On Striking a Thyratron by Positive Grid Impulses.—V. L. Inosov. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1937, pp. 9–16.)

A report on an experimental investigation of the relationship between the magnitude of the positive impulse applied to the grid of a thyratron and the duration of this impulse necessary for the thyratron to strike. Rectangular impulses were obtained by discharging a condenser through a momentary contact, the latter being effected by swinging a small steel ball connected to one side of the condenser against a steel plate connected to the other side. The duration of the impulse was regulated by adjusting the initial deflection of the ball and by using balls of different diameters. In this way impulses lasting from 30 to 100 μsec. were obtained.

It appears from this investigation that the striking of a thyratron by positive impulses is very irregular and that it can only be predicted with a certain degree of probability. A table is however given (p. 16) showing, for impulses ranging from + 2 V to + 15 V, the shortest durations necessary to ensure that the thyratron will strike (100 to 45 μsec).

2349. A NEW RECTIFIER WITH CATHODE HEATED UP BY PRELIMINARY GLOW DISCHARGE TURNING TO ARC.—Grau. (*Elektrot. u. Maschbau*, 25th Feb. 1937, Vol. 58, No. 8, p. 226.) After the ignition (taking only a fraction of a second) the rectifier works for voltages down to 12 volts.

2350. A COLD-CATHODE RECTIFIER [Improved Form].—Knipp. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, p. 377 : abstract only.)

2351. THE STROBOTRON [Its Various Applications and Circuits : Starting Characteristics].—Germeshausen, Edgerton, & others. (*Electronics*, Feb. & March 1937, Vol. 10, Nos. 2 & 3, pp. 12–14 and 18–21.)

2352. AN ELECTRIC DISCHARGE STROBOSCOPIC TUBE [Mercury-Vapour, Hot-Cathode, with Four Starting Electrodes]. — British Thomson-Houston. (*Electrician*, 9th April 1937, Vol. 118, pp. 494–495.)

2353. THE GROWTH-TIME OF A GLOW DISCHARGE [Theory and Experiment on Neon Discharge].—Schade. (*Zeitschr. f. Physik*, No. 7/8, Vol. 104, 1937, pp. 487–510.)

2354. CARBONISED EMISSIVE ELECTRODES AND "BIELECTRODES" FOR DISCHARGE TUBES.—Abadie. (*Bull. Soc. franc des Élec.*, March 1937, Vol. 7, No. 75, pp. 377–378 : summary only.)

To give long life. Emissive electrodes in a.c. driven tubes are destroyed when they act as anodes and not when they act as cathodes : this effect is connected with the anode drop of potential, and the "bielectrodes" described make use of this fact.

2355. ON THE QUESTION OF THE PROPERTIES OF THE BARRIER LAYER IN "VALVE-LAYER" PHOTOCELLS.—Jouse. (*See* 2294.)

2356. AN ANALYSIS OF COPPER-OXIDE RECTIFIER CIRCUITS.—Huss. (*Elec. Engineering*, March 1937, Vol. 56, No. 3, pp. 354–360 and 366, 367.)

2357. ON THE NATURE OF THE ELECTROLYTIC DEPOLARISING EFFECT OF A HIGH-FREQUENCY CURRENT [Experiments at 3 Mc/s Frequency proving Effect to be Purely Thermal].—Ranzi & Ricamo. (*Nuovo Cimento*, Jan. 1937, Vol. 14, No. 1, pp. 1–7.)

2358. NEW INVESTIGATIONS ON BRUSH DISCHARGES [Gleitentladungen].—Baasch. (*Bull. Assoc. suisse des Élec.*, No. 7, Vol. 28, 1937, pp. 147–149 : in German.)

"Surface discharges often reduce the spark-over voltages of insulators, condensers, etc., seriously below the value expected on grounds of the air distance ; this explains the great importance, for the industry, of preventing their occurrence. Of special importance, particularly at high voltages, are the brush discharges—generally best known in the form of Lichtenberg figures. The present paper describes new researches on internally metallised insulating tubes." The writer is led to the hypothesis that the electrons projected by the negative point on to the surface partly covered with positive ions do not neutralise themselves immediately with these ions but group themselves in a superficial negative charge side by side with the positive. When the numbers of electron and ion charges are equal, a "quasi-neutral" state occurs, and the insulator surface appears neutralised, though in reality holding both a positive and a negative charge on its surface. The electrical resistance of such a quasi-neutral zone is very slight compared with a true neutral zone, and heavy-current discharges can readily occur and (owing to the small voltage-drop in the quasi-neutral zone) attain great lengths. Oscillographic and stroboscopic results are given.

2359. IMPULSE-VOLTAGE STRENGTH OF INSULATORS AND MATERIALS [concerned in Lightning Protection].—Dowell & Foust. (*Gen. Elec. Review*, March 1937, Vol. 40, No. 3, pp. 141–152.)

2360. A CONTRIBUTION TO THE FLASH-OVER PROBLEM [of Pin-Type Insulators].—Eisler. (*See* 2142.)

2361. CERAMICS AS INSULATORS [Survey].—(*Electronics*, Feb. 1937, Vol. 10, No. 2, pp. 7–10.)

2362. C.E.I. SCHEME OF STANDARDS AND INSTRUCTIONS FOR TESTS ON DIELECTRICS.—(*L'Elettrotec.*, No. 4, Vol. 24, 1937, Supplement : 11 pp.)

2363. THE PROPERTIES OF A DIELECTRIC CONTAINING SEMICONDUCTING PARTICLES OF VARIOUS SHAPES [Experimental Results (Almost Spherical Water Drops in Wax) disagreeing with Wagner's Analysis : Analysis of Case of Spheroidal Particles : etc.].—Sillars. (*Journ. I.E.E.*, April 1937, Vol. 80, No. 484, pp. 378–394.)

"It is concluded that a minute amount of conducting impurity in the form of fine needles could produce a serious loss at low frequencies, although the effect of the same quantity of impurity in spherical form would be negligible."

2364. EFFECTS OF ULTRA-VIOLET RAYS ON THE ELECTRICAL CONDUCTIVITIES OF SOLID INSULATORS.—Shimizu. (*Journ. I.E.E. Japan*, Oct. 1936, Vol. 56 [No. 10], No. 579, pp. 1042–1048 : English summary p. 81.)

2365. ON THE ELIMINATION OF EDGE EFFECT OF ELECTRODES IN THE BREAKDOWN OF SOLID DIELECTRICS [by the Use of Sputtered Film].—Saito. (*Journ. I.E.E. Japan*, Oct. 1936, Vol. 56 [No. 10], No. 579, pp. 1036–1041 : English summary pp. 80–81.)

2366. A [Direct, Electrical] METHOD OF MEASURING THE THERMAL CONDUCTIVITY OF INSULATING MATERIALS.—Weh. (*Gen. Elec. Review*, March 1937, Vol. 40, No. 3, pp. 138–140.)

2367. NEW INSULATING MATERIALS : SIPA 14, MIPOLAM, TROLITUL III, TROLITUL LUV (LUVICAN), ETC.—(*E.T.Z.*, 4th March 1937, Vol. 58, No. 9, p. 254.)

2368. A New Ceramic Insulator, Kerafar U, and Some Condensers [including the "Multi-Hole" or "Chessboard" Type].—(*E.T.Z.*, 25th Feb. 1937, Vol. 58, No. 8, p. 227.)

2369. Regulating Condensers [Leakage Current of Wet Electrolytic Condenser utilised to prevent High Switch-On Voltage Rises in Receivers: Required Leakage Characteristic obtained by Correct Composition of Solution].—Aerovox Company. (*Rad. Engineering*, Oct. 1936, Vol. 16, No. 10, pp. 11–12.)

2370. "Elektrolyt-Kondensatoren" [Book Review].—Güntherschulze & Betz. (*Electrician*, 2nd April 1937, Vol. 18, p. 458.)

2371. Instrument for the Direct Measurement of the Figure of Merit (Megohms × Microfarads) of Small Condensers.—Gönningen. (*See* 2309.)

2372. Mersea Island Sea-Corrosion Testing Station [and the Akure Tropical Test Station].—Robinson. (*Marconi Review*, Nov./Dec. 1936, No. 63, pp. 12–18.)

2373. Finishes for Radio Apparatus [and the Need for Selection of Suitable Composition for Each Purpose: Examples].—Klinkenstein. (*Rad. Engineering*, Feb. 1937, Vol. 17, No. 2, pp. 22 and 27.)

2374. A New Method of Measuring the Ferromagnetic Properties of Metals at Ultra-High and Micro-Wave Frequencies.—Potapenko & Sänger. (*See* 2302.)

2375. Some Uses of the Torque Magnetometer [Measurement of Anisotropy Constants, Coercive Force, Rotational Hysteresis Losses, etc.].—Williams. (*Review Scient. Instr.*, Feb. 1937, Vol. 8, No. 2, pp. 56–60.)

2376. Method of Measuring the Losses in [Small Specimens of] Magnetic Sheets.—di Pieri. (*L'Elettrotec.*, No. 6, Vol. 24, 1937, pp. 160–162.)

2377. Coils with Compressed-Powder Cores of Small Hysteresis for Carrier-Frequency Telephony.—Kersten & Hesse. (*E.N.T.*, Feb. 1937, Vol. 14, No. 2, pp. 66–74.)

These coils were developed in order to avoid the use of non-ferromagnetic cores and so to economise in space and copper. The theory of the limiting hysteresis conditions to be satisfied is given in § 1; they are compared with those recommended by the CCI. The permissible amount of hysteresis is defined by the necessary limits to the non-linear cross-talk between the various frequency channels; this leads to a discussion of the connection between the hysteresis resistance and the "klirr" factor. § 2 describes how the choice and treatment of the core material satisfied the hysteresis conditions; a special carbonyl iron powder with very good magnetic stability was used. § 3 gives some experimental data of the comparative losses in various parts of the coil and some remarks on its construction and winding; very low values of loss angle were found.

2378. Study of Dust Core for High-Frequency Coils [obtained from Factory "Scale" by Reduction and Powdering: giving Coils with $Q = 140$ at 1 Mc/s].—Sanehudi. (*Journ. I.E.E. Japan*, Dec. 1936, Vol. 56 [No. 12], No. 581, pp. 1222–1226: English summary p. 95.)

2379. High-Frequency Magnetic Material ["Magicore": a Magnesium-Ferrous Alloy Powder with Crolite Ceramic Binder].—Crowley. (*Rad. Engineering*, Oct. 1936, Vol. 16, No. 10, pp. 15–16.)

2380. Variation of the Magnetic Susceptibility of a Haematite Powder as a Function of the Size of the Granules [Susceptibility decreases with Granule Diameter].—Chevalier & Mathieu. (*Comptes Rendus*, 15th March 1937, Vol. 204, No. 11, pp. 854–856.)

2381. The Law of the Magnetisation of Ferromagnetic Substances in Weak Fields [Rayleigh's Law and Jordan's Development: the Importance of the Rayleigh-Jordan Relations in Telephone Engineering].—Kersten. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 18, 1937, pp. 39–41.)

2382. An Explanation for Directions of Easy Magnetisation in Ferromagnetic Cubic Crystals [in Terms of Distribution of Magnetic Dipoles in Atoms of Iron and of Nickel].—Bozorth & McKeehan. (*Phys. Review*, 1st Feb. 1937, Series 2, Vol. 51, No. 3, p. 216.)

2383. The Dependence of the Magnetic After-Effect [of Iron/Nickel Alloys] on Internal Tensions [Experimental Curves].—Kindler. (*Ann. der Physik*, Series 5, No. 4, Vol. 28, 1937, pp. 375–384.)

2384. Torsion of an Iron or Nickel Wire facilitates Magnetisation Discontinuities with an Axial Alternating Current.—Procopiu & Vasiliu. (*Comptes Rendus*, 22nd March 1937, Vol. 204, No. 12, pp. 971–973.)

2385. A Theory of the Ferromagnetism of Alloys [giving Dependence of Spontaneous Magnetisation on Temperature for Any Homogeneous Phase: Possibilities of More than One Critical Temperature and of Chemical Separation].—Bitter. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, p. 383: abstract only.)

2386. On the Exchange Interaction in Magnetic Crystals.—Opechowski. (*Physica*, March 1937, Vol. 4, No. 3, pp. 181–199: in English.)

2387. An Equivalent Equation for the Hysteresis Loop: II.—Sedlmayr. (*Elektrot. u. Maschinenbau*, 28th March 1937, Vol. 55, No. 13, pp. 153–156.) *Cf.* 3235 of 1935 and 1983 of 1936.

2388. THE ELECTRICAL CONDUCTIVITY OF THIN FILMS OF THE ALKALI METALS SPONTANEOUSLY DEPOSITED ON GLASS SURFACES [with Evidence for regarding Films as Monatomic Layers].—Lovell. (*Proc. Phys. Soc.*, 1st March 1937, Vol. 49, Part 2, No. 271, pp. 89–94.)

2389. THE STRUCTURE AND ELECTRICAL CONDUCTIVITY OF THIN FILMS OF INDIUM [Effect of Adsorbed Gas].—Cosslett. (*Proc. Phys. Soc.*, 1st March 1937, Vol. 49, Part 2, No. 271, pp. 121–131 : Discussion pp. 131–133.)

2390. AUTOMATIC STARTING RESISTANCE [" Starto " Tubes of Semiconductor (Silicon with Ceramic Binder) in Argon, giving High Resistance when Cold and Low when Hot].—Philips Company. (*Electronics*, Feb. 1937, Vol. 10, No. 2, p. 62.)

2391. THE USE OF URDOX RESISTANCES IN ELECTRICAL APPARATUS.—Werner. (*Zeitschr. f. Fernmeldetech.*, No. 1, Vol. 18, 1937, pp. 15–16.)

2392. D.C. AMPLIFIER FOR MAINS CONNECTION WITH COMPENSATION OF VOLTAGE VARIATIONS.—Reisch. (*Hochf:tech. u. Elek:akus.*, Feb. 1937, Vol. 49, No. 2, pp. 49–52.)

The magnitude of the effect of variations of the mains voltage on a d.c. amplifier, without and with voltage stabilisation by glow-discharge tubes, is first discussed theoretically with reference to a circuit (Fig. 1) given by Holzer (1166 of 1936). A circuit (Fig. 2) is then described in which the sensitivity to voltage variations is reduced by correct mutual balancing of the degree of stabilisation of the various feeding voltages.

2393. AUTOMATIC SIPHON TAPE RECORDER [for Code Signals direct from Radio Receiver].—Sidoroff. (*Comm. & Broad. Eng.*, March 1937, Vol. 4, No. 3, p. 22.)

2394. AN ELECTRONIC-TYPE OSCILLOGRAPHIC FREQUENCY-RESPONSE CURVE APPARATUS OF WIDE APPLICATION.—Gordon & Mutton. (*See* 2144.)

2395. A NEW MULTI-COMPONENT RECORDER FOR CHARACTERISTIC CURVES.—Awender & Tombs. (*See* 2175.)

2396. A D.C. AMPLIFIER FOR LOGARITHMIC RECORDING.—Taylor. (*See* 2065.)

2397. CALCULATION AND CONSTRUCTION OF OSCILLOGRAPH STRINGS [excited Electrodynamically : Approximate Formulae : Current Sensitivity decreases with Cube of Natural Frequency].—Söchting. (*Arch. f. Elektrot.*, 23rd Jan. 1937, Vol. 31, No. 1, pp. 31–40.)

2398. A CIRCUIT FOR COUNTING IMPULSES AT HIGH SPEEDS OF COUNTING [Effect of a Given Number of Pulses integrated to give One Count].—Griffiths. (*Proc. Phys. Soc.*, 1st March 1937, Vol. 49, Part 2, No. 271, pp. 85–88.)

2399. A NEW METHOD OF VIEWING FILMS AND PLATES [ordinarily viewed as Transparencies : Increased Contrast obtained by Double Passage through Sensitised Layer].—Wolf & Riehl. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 18, 1937, pp. 89–90.)

By backing the film or plate with a fluorescent surface and illuminating from front with ultra-violet light (first passage) : the visible rays of fluorescence pass out (second passage) to eye.

STATIONS, DESIGN AND OPERATION

2400. EXPERIMENTS IN WIRELESS TELEPHONY ON 400 MEGACYCLES/SECOND [Tests around Geneva with Very Portable Transceivers using " Acorn " Valves Type 955 for Transmitting and Receiving].—Luthi. (*Bull. Assoc. suisse des Élec.*, No. 5, Vol. 28, 1937, pp. 103–106 : in French.)

An enthusiastic report on the performance of these sets : using reflectors of vertical rods, perfect two-way conversations were maintained at distances up to 120 km (grazing optical path).

2401. 60-MEGACYCLE TELETYPEWRITER [Bureau of Air Commerce 40-Mile Washington/Baltimore Circuit].—Martin. (*Electronics*, March 1937, Vol. 10, No. 3, pp. 10–11.) The aerials are 800 ft below the line of sight.

2402. THE BROADCASTING SERVICE DURING THE XI OLYMPIC GAMES IN BERLIN.—Wratzke & Schrock. (*T.F.T.*, Jan. 1937, Vol. 26, No. 1, pp. 10–13.)

2403. THE RELAY STATIONS OF THE HUNGARIAN BROADCASTING SYSTEM.—Tomits. (*Rev. Gén. de l'Élec.*, 27th March 1937, Vol. 41, No. 13, p. 100D : summary only.)

2404. SHORT-WAVE BROADCAST TRANSMITTER FOR BRITISH INDIA.—(*Philips Transmitting News*, March 1937, Vol. 4, No. 1, pp. 15–17.)

2405. WHAT WE DONT KNOW ABOUT RADIO [Some FCC Queries to Radio Engineers].—(*Electronics*, Feb. 1937, Vol. 10, No. 2, p. 5.) For instance, " what constitutes a favourable ratio between desired and undesired signals ? "

GENERAL PHYSICAL ARTICLES

2406. ELECTRON GAS IN A MAGNETIC FIELD.—Lifschitz. (*See* 2157.)

2407. THE CHARGE ON THE ELECTRON [New Value of Air Viscosity, with Oil-Drop Data, gives Agreement with X-Ray Value].—Bearden. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, p. 378 : abstract only.)

2408. A DETERMINATION OF h/e FROM THE SHORT WAVELENGTH LIMIT OF THE CONTINUOUS X-RAY SPECTRUM.—DuMond & Bollman. (*Phys. Review*, 15th March 1937, Series 2, Vol. 51, No. 6, pp. 400–429.)

2409. PROTON-NEUTRON TRANSFORMATION UNDER ACTION OF GAMMA RADIATION [Calculation of Probability].—Rumer. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 11, 1937, pp. 48–54 : in German.)

2410. CONCENTRATION OF NEUTRON BEAMS [by Paraffin Lenses].—Lewis & Schutz. (*Science*, 12th March 1937, Vol. 85, Supp. p. 10.)

2411. ON THE LAWS OF DISTRIBUTION OF VELOCITIES OF PARTICLES UNDERGOING EMISSION AND ABSORPTION IN A RADIATION FIELD.—Kishen & Saha. (*Indian Journ. of Phys.*, Part 6, Vol. 10, 1936, pp. 413–419.)

2412. A SPECTROSCOPIC STUDY OF THE MAGNETRON DISCHARGE [in Helium: Evidence for Presence of He^{++} Ions from Intensity of He II Spectrum: Efficiency of Magnetron Source in Producing Higher Ionisation States].—Luhr & Studer. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, pp. 306–310.)

MISCELLANEOUS

2413. CONTOUR INTEGRAL EXPRESSIONS FOR POTENTIAL FUNCTIONS.—McLachlan & Meyers. (*Phil. Mag.*, April 1937, Series 7, Vol. 23, Supp. No. 156, pp. 762–774.)

2414. SOME SERIES CONNECTED WITH BESSEL FUNCTIONS [generalising and extending Them].—Delsarte. (*Comptes Rendus*, 31st March 1937, Vol. 204, No. 13, pp. 1024–1026.)

2415. IMMERSION OF THE FOURIER TRANSFORM IN A CONTINUOUS GROUP OF FUNCTIONAL TRANSFORMATIONS.—Condon. (*Proc. Nat. Acad. Sci.*, March 1937, Vol. 23, No. 3, pp. 158–164.)

2416. A NOTE ON LAGUERRE POLYNOMIALS.—Howell. (*See* 2149.)

2417. ON THE CALCULATION OF ERRORS [Analysis and Formulae for Erratic Experimental Errors].—DeVore. (*Phys. Review*, 1st March 1937, Series 2, Vol. 51, No. 5, pp. 349–354.)

2418. THE FUNCTIONS ASSOCIATED WITH A RING OF OVAL CROSS SECTION.—Lebedev. (*Tech. Phys. of USSR*, No. 1, Vol. 4, 1937, pp. 3–24: in English.)

2419. THE INFLUENCE OF THE WATER CONTENT ON THE RESISTANCE OF GEOLOGICAL CONDUCTORS.—Fritsch. (*See* 2051.)

2420. A NEW TECHNIQUE FOR THE DEMONSTRATION AND INVESTIGATION OF NERVE ACTION CURRENTS AND OTHER SHORT-TIME PHENOMENA.—Schmitz. (*See* 2192.)

2421. ON THE "TIEFENWIRKUNG" [Deep Action] IN ULTRA-SHORT-WAVE THERAPY.—Takagisi. (*Journ. I.E.E. Japan*, Nov. 1936, Vol. 56 [No. 11], No. 580, p. 1188: Japanese only.)

2422. "BEITRÄGE ZUR PHYSIK DER WÜNSCHELRUTENFRAGE" [Divining Rod Problem: Book Review].—Fritsch & Jelinek. (*Elektrot. u. Maschbau*, 14th March 1937, Vol. 55, No. 11, p. 136.)

2423. PRESENT TENDENCIES OF POWER DEVELOPMENT AND THEIR REPERCUSSIONS UPON TELECOMMUNICATION SYSTEMS. — Frost. (*P.O. Elec. Eng. Journ.*, April 1937, Vol. 30, Part 1, pp. 1–14.)

2424. A SURVEY OF MARINE RADIO PROGRESS, WITH SPECIAL REFERENCE TO R.M.S. *Queen Mary*.—Loring, McPherson, & McAllister. (*Nature*, 10th April 1937, Vol. 139, pp. 621–622: short note on recent I.E.E. paper.)

2425. PROGRESS IN ENGINEERING KNOWLEDGE DURING 1936, *and* DEVELOPMENTS IN THE ELECTRICAL INDUSTRY DURING 1936.—Alger: Liston. (*Gen. Elec. Review*, Dec. 1936, Vol. 39, pp. 572–587: Jan. 1937, Vol. 40, No. 1, pp. 5–63.)

2426. SCIENTIFIC PROPERTY [and the Proposal to Protect Scientific Discoveries and Inventions whether Patentable or Not].—Williamson. (*Journ. Scient. Instr.*, March 1937, Vol. 14, No. 3, pp. 73–76.)

2427. MORE ABOUT SCIENTIFIC ENGLISH.—Rickett. (*Science*, 8th Jan. 1937, Vol. 85, pp. 45–46.) For previous letters *see* 776 of February.

2428. DISSEMINATION OF SCIENTIFIC LITERATURE BY MEANS OF MICROFILMS, *and* MICROFILMS HAILED AS NEW WAY TO DUPLICATE BOOKS, PICTURES.—Seidell: Davis. (*Science*, 5th March 1937, Vol. 85, pp. 240–242: *Science News Letter*, 20th March 1937, Vol. 31, pp. 179–180.)

2429. ELECTRICAL VOCABULARY PREPARED BY IEC ["International Vocabulary" to be published during 1937].—(*Elec. Engineering*, April 1937, Vol. 56, No. 4, p. 496.)

2430. "LEHRBUCH DER HOCHFREQUENZTECHNIK" [Book Review].—Vilbig. (*T.F.T.*, Jan. 1937, Vol. 26, No. 1, pp. 23–24.)

2431. SHOULD YOU CHOOSE RADIO ENGINEERING AS A CAREER? PRACTICAL SUGGESTIONS FOR DETERMINING YOUR OWN VOCATIONAL FITNESS.—Merrill. (*QST*, April 1937, Vol. 21, No. 4, pp. 52–53 and 112, 114, 116, 118.)

2432. ELECTRON APPARATUS AT THE PHYSICAL SOCIETY'S EXHIBITION.—(*Television*, Feb. 1937, Vol. 10, No. 108, pp. 76–77 and 78.)

2433. RADIO TECHNIQUE AT THE LEIPZIG FAIR.—Schwandt. (*Funktech. Monatshefte*, March 1937, No. 3, pp. 99–102.)

2434. ELECTROMAGNETIC METHOD OF DETECTING BROKEN STRANDS IN STEEL-WIRE CABLES.—Darré & Wellenstein. (*Zeitschr. V.D.I.*, 30th Jan. 1937, Vol. 81, pp. 134–135.)

2435. MEASURING [Smoothness & Hardness of Surface of] TEXTILE GELATINES WITH A PHONOGRAPH PICK-UP.—Saxl. (*Electronics*, Jan. 1937, Vol. 10, pp. 40 and 42, 44.)

2436. PNEUMATIC AMPLIFICATION ["Solex" Air-Jet Micrometer and Its Applications].—Mennesson. (*Génie Civil*, 20th March 1937, Vol. 110, pp. 276–277.)

Some Recent Patents

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each. A selection of abstracts from patents issued in the U.S.A. is also included, and these bear a seven-figure serial number.

AERIALS AND AERIAL SYSTEMS

458 018.—Means for winding up the trailing aerial used in aircraft radio sets.

Romeylowerk Ges. fur Drahtlose Telegraphie. Convention date (Germany) 5th June, 1935.

458 084.—Aerial with flexible down-lead arranged to receive (*a*) short-wave or (*b*) medium and long-wave signals.

Marconi's W.T. Co. and N. M. Rust. Application date, 8th June, 1935.

458 150.—Circularly arranged system of aerials designed to radiate a flattened field without any marked directivity in the horizontal plane.

Soc. Francaise Radio-Electrique. Convention date, (France) 13th April, 1935.

TRANSMISSION CIRCUITS AND APPARATUS.

459 235.—Wireless telephony system in which subscribers are given two-way communication in the same way as overland-lines.

Wallace and Tiernan Products Inc. (assignees of J. R. Hackay). Convention date (U.S.A.) 11th June, 1934.

459 303.—Piezo-electric oscillator for "wobbling" the carrier-wave frequency in a secret system of wireless telephony.

Marconi's W.T. Co. and T. D. Parkin. Application date 5th July, 1935.

459 348.—Regulating reaction in a "three-point" valve circuit used for generating very short waves.

Telefunken Co. Convention date (Germany) 8th June, 1935.

RECEPTION CIRCUITS AND APPARATUS

457 721.—Short-wave receiver of the superhet or super-regenerative type, employing a magnetically controlled split-anode valve.

C. Lorenz Akt. Convention dates (Germany) 25th February, 10th April, and 16th August, 1935.

458 059.—"Geographical" tuning-scale or indicator for a wireless receiver.

F. I. Magneti Marelli. Convention date (Italy) 6th February, 1935.

458 147.—Eliminating re-radiation from a superhet receiver by means of a hexode mixing-valve.

Radio-Akt D. S. Loewe. Convention date (Germany) 12th March, 1935.

458 235.—Muting circuit for a wireless receiver in which a discharge tube operates as an attenuator.

Standard Telephones and Cables (assignees of H. M. W. E. Reichle and G. N. Thayer). Convention date (U.S.A.) 19th June, 1935.

458 861.—Valve amplifying circuit arranged to prevent distortion due to grid current.

Baird Television, G. W. White, A. J. Brown, and P. W. Willans. Application date, 27th May, 1935.

459 251.—Amplifier circuit giving a uniform gain over a wide band of frequencies.

The General Electric Co., G. W. Edwards, and D. C. Espley. Application date, 31st October, 1935.

460 305.—Wireless receiver with single-span tuning control over a wide frequency range.

E. K. Cole and R. I. Cowley. Application date, 30th August, 1935.

460 673.—Screen-grid amplifier arranged so that the anode voltage keeps in phase with the control-grid voltage.

T. H. Bridgewater. Application date 26th September, 1935.

461 330.—Circuit for suppressing "whistles" in a wireless receiver without cutting-out the corresponding frequency from the signal.

E. K. Cole and A. E. Falkus. Application date 15th August, 1935.

461 763.—Ultra-short-wave circuit utilising a negative conductance effect produced between the electrodes of the valve.

Standard Telephones and Cables (assignees of Le Materiel Telephonique Soc. Anon.) Convention date (France) 24th November, 1934.

VALVES AND THERMIONICS

457 928.—Utilising a space-charge effect to increase the efficiency of a screen-grid valve when operating either as an amplifier or frequency-changer.

N. V. Philips' Lamp Co. Convention date (Germany) 9th August, 1934.

DIRECTIONAL WIRELESS

457 681.—Direction-finding system in which the desired bearings are shown as a direct luminous indication on a geographical chart.

J. Marique and S. A. Internationale de T.S.F. Convention date (Belgium) 24th January, 1935.

457 771.—Oscillation-generator of the multi-vibrator type for use with direction-finding systems utilising overlapping beams of radiated energy.

Marconi's W.T. Co. and N. H. Clough. Application date 31st May, 1935.

458 734.—Monitoring arrangement for radio navigational transmitters of the overlapping-beam type.

Telefunken Co. Convention date (Germany) 4th June, 1935.

460 488.—Preventing the repetition of "direct" and "space-wave" signals in direction finding systems.

Telefunken Co. Convention date (Germany) 24th May, 1935.

460 883.—Safety arrangement for radio-navigational systems of the overlapping-beam type.

Telefunken Co. Convention date (Germany) 24th September, 1935.

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

458 287.—Loud speaker with a rotating magnetic core designed to apply the driving force in the plane of greatest mechanical strength and with maximum efficiency.

H. Vogt. Convention dates (Germany) 3rd November, 1934 and 1st October, 1935.

TELEVISION AND PHOTOTELEGRAPHY

457 531.—Cathode-ray television transmitters of the Iconoscope type.

J. D. McGee, G. S. P. Freeman, and W. S. Brown. Application date 6th June, 1935.

457 757.—Arrangement of the accelerating and other electrodes in a cathode-ray television receiver.

Radio-Akt. D. S. Loewe. Convention date (Germany) 3rd March, 1934.

457 800.—Limiting the intensity of the cathode-ray stream in a television receiver in order to prevent spurious "flashes" on the screen due to interference.

A. G. D. West and Baird Television. Application date 5th June, 1935.

458 382.—Means for preventing undesired "after-glow" on the fluorescent screen of a television receiver.

Scophony, J. D. Baynes, and G. Wikkenhauser.

458 586.—Preparing a photo-electric mosaic-cell surface for use in a cathode-ray tube.

L. Klatzow. Application date 20th March, 1935.

459 042.—Television system in which a high-speed rotating lens is combined with a moving shutter and a parallel slit for scanning purposes.

H. Vierl. Convention date (Germany), 27th March and 11th October, 1934.

459 178.—Generating saw-toothed oscillations for "cross-scanning" in television apparatus.

J. C. Wilson and Baird Television. Application date 4th July, 1935.

459 400.—Television system in which a high rate of picture repetition is used in combination with interlaced scanning.

Farnsworth Television Inc. Convention date (U.S.A.) 5th November, 1934.

459 735.—Constant-gain amplifiers for transmitting television signals.

The General Electric Co. and D. C. Espley. Application dates, 24th October, 1935 and 14th July, 1936.

459 963.—Protecting device for cathode-ray television receivers.

The General Electric Co. and D. C. Espley. Application date 22nd October, 1935.

460 204.—A television receiver in which a picture recorded on a photographic film is projected, before the film is dried, on to a viewing screen.

T. E. Bray and Baird Television. Application date 22nd July, 1935.

SUBSIDIARY APPARATUS AND MATERIALS

457 820.—Meters for measuring the frequency of electric oscillations independently of variations in voltage.

Standard Telephones and Cables and V. J. Terry. Application date, 7th June, 1935.

458 032.—Photo-electric amplifier in which "fatigue" effects are automatically offset.

S. Vasilach. Convention date (France) 6th June, 1934.

458 270.—High-speed cathode-ray tube with means for trapping "retrograde rays" which travel with the main electron stream.

R. V. Whelpton and Metropolitan Vickers Electrical Co. Application date 24th June, 1935.

458 635.—Method of preparing fluorescent screens from inorganic oxides by vaporisation and precipitation.

N. V. Philips' Lamp Co. Convention date (Germany) 29th May, 1935.

458 691.—Compensating for the effect of temperature-change in electrical tuning devices, particularly condensers.

H. W. Sullivan and W. H. F. Griffiths. Application date 26th June, 1935.

458 746.—Maintaining the electron stream of a cathode-ray tube in correct focus, in spite of variation in the deflecting potentials, or in spite of the fact that the stream travels over a surface of varying curvature.

J. E. Keyston, F. H. Nicoll, and O. Klemperer. Application dates 19th March and 7th May, 1935.

458 889.—Dry contact rectifier in which two electrodes of different emissive power are separated by a layer of solid non-conducting material.

N. V. Philips' Lamp Co. Convention date (Germany) 1st June, 1935.

MISCELLANEOUS

458 307.—Signalling system, particularly for aerodromes, in which a wireless transmitter and also a group of Neon lamps, are supplied from the same high-frequency source.

J. Fodor. Application date 16th March, 1935.

458 450.—Resistance-capacity-coupled amplifier designed to have a large time-constant and adapted for measuring heart-beats.

Marconi's W.T. Co. and O. E. Keall. Application date, 21st June, 1935.

458 505.—Low-loss composition, including finely divided magnetic particles, for conducting high-frequency currents.

F. K. Nagelschmidt. Application date 17th April, 1935.

459 645.—Self-levelling mounting for piezo-electric crystal oscillators.

Marconi's W.T. Co. (assignees of H. J. Schrader and R. F. Bov). Convention date (U.S.A.) 14th June, 1935.